AIRSHIP DESIGN CRITERIA

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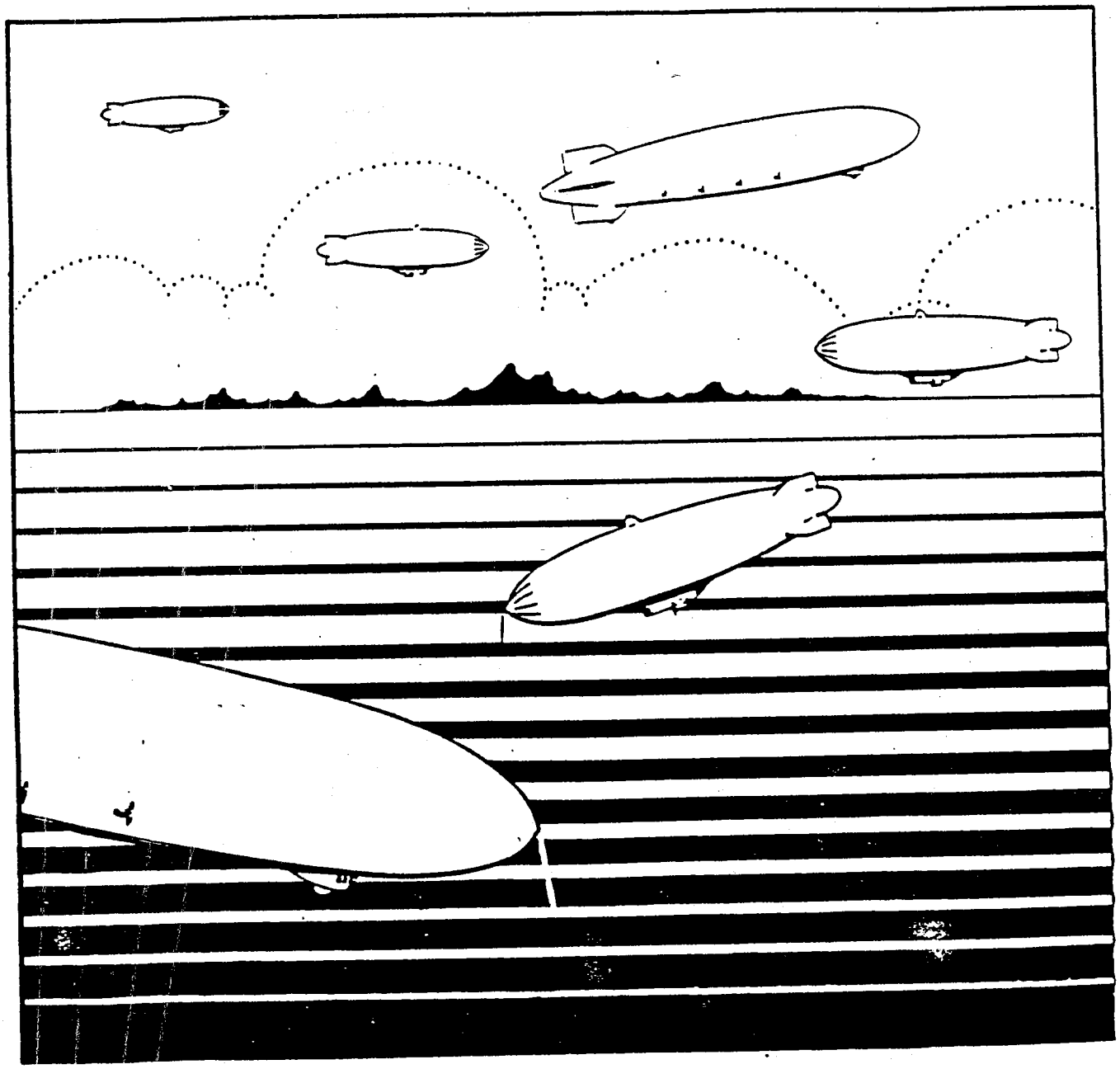

CHANGE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FAA-P-8110-2
CHG 2

2/6/95

SUBJ: AIRSHIP DESIGN CRITERIA

1. PURPOSE. This change transmits replacement pages as shown below.

2. EXPLANATION OF CHANGES. This change adds the requirements for a fly-by-light control system. Two new paragraphs have been added to the ADC that cover concerns related to optical couplings and optical degradation. The requirements for a control system not directly (mechanically) connected to the control surface are applicable to both fly-by-wire and fly-by-light. The fiber optics used in fly-by-light systems, though immune to some of the problems associated with fly-by-wire systems, have their own set of problems. Those problems are addressed in this change. The change number appears at the bottom of the affected pages. The asterisks (*) in the right and left margins indicate the beginning and end of the change.

3. DISPOSITION OF TRANSMITTAL. After filing the revised pages, the change transmittal should be retained.

PAGE CONTROL CHART

Remove Pages	Dated	Insert Pages	Dated
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MICHAEL K. DAHL
Acting Manager, Small Airplane Directorate
Aircraft Certification Service

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CHANGE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

FAA-P-8110-2
CHG 1

7/24/92

SUBJ: AIRSHIP DESIGN CRITERIA

1. PURPOSE. This change transmits replacement pages as shown below and a new Appendix B.

2. EXPLANATION OF CHANGES. Federal Aviation Administration Report P-8110-2, Airship Design Criteria (ADC), issued November 2, 1987, contains the first acceptable design criteria for type certification of airships. Since that time, we have made one revision to the ADC. This change was noticed in the Federal Register on June 15, 1989; however, the change was never incorporated into the ADC. While applying this version of the ADC to actual type certification projects, we discovered portions of the report that required additional clarification or revision. These changes have been incorporated in this report and an explanation of these changes is contained in Appendix B. The change number appears at the bottom of the affected pages. The asterisks (*) in the right and left margins indicate the beginning and end of the change.

3. DISPOSITION OF TRANSMITTAL. After filing the revised pages, the change transmittal should be retained.

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John R Colomy

JOHN R. COLOMY
Acting Manager, Small Airplane Directorate
Aircraft Certification Service

Distribution: ANE-100, ANM-100, ASW-100, AIR-100, ACE-107, ACE-109, ACE-115A, ACE-115C, ACE-115N, ACE-115W, AEU-100, ANE-150, ANE-170, ANM-100L, ANM-100S, ANM-191A, ANM-191D, ASW-150, ASW-190

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INTRODUCTION

The purpose of this report is to provide acceptable airworthiness requirements for the type certification of conventional, near-equilibrium, nonrigid airships. This report contains the design requirements necessary to provide an equivalent level of safety to that prescribed in FAR 21.17(b) for special classes of aircraft. These criteria are applicable to airships certificated in the normal category that have a passenger seating configuration, excluding pilot seats, of nine seats or less. For airships containing larger numbers of passengers, these criteria would require further consideration. These Airship Design Criteria are referenced in Advisory Circular (AC) 21.17-1, "Type Certification-Airships," as an acceptable means for the type certification of conventional, nonrigid airships. There are additional requirements presented in the AC.

The AC provides background information on the development of these criteria. It also provides the procedures necessary to obtain a U.S. type certificate for airships. Both these criteria and the AC are necessary documents for persons interested in obtaining a U.S. type certificate for an airship. It should be noted that the airship design criteria contained in this report is only one acceptable means of compliance to the type certification of airships. The AC provides procedures for other persons to develop and obtain Federal Aviation Administration (FAA) approval for their own design criteria, which may utilize all or part of these criteria. These criteria may be revised as the need arises. As experience is gained with U.S. airship certification programs the FAA may consider establishing airship airworthiness standards as a separate part of the Federal Aviation Regulations.

M.C. Beard
Director of Airworthiness

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AIRSHIP DESIGN CRITERIA

SUBPART I - GENERAL

1.1 Applicability.

These criteria prescribe acceptable airworthiness requirements, applicable to nonrigid, near-equilibrium, conventional airships, for the issuance of type certificates and changes to those certificates under Part 21.17(b) of the Federal Aviation Regulations (FAR). These criteria are applicable to airships certificated in the normal category that have a passenger seating configuration, excluding pilot seats, of nine seats or less. Additional requirements may be required to cover airship design features or operational characteristics not envisioned in this document as discussed in Advisory Circular 21.17-1.

1.2 Definitions.

The following apply:

(a) An airship is an engine-driven, lighter-than-air aircraft, that can be steered.

(b) A nonrigid airship is one whose structural integrity and shape is maintained by the pressure of the gas contained within the envelope.

(c) A near-equilibrium airship is one which is capable of achieving zero static heaviness during normal flight operations.

(d) A car is a structure attached to or suspended from the envelope for carrying crewmembers, passengers, cargo, equipment, or propulsion systems.

(e) Pressure height is the altitude at which the lifting gas fills the envelope with the ballonets completely deflated.

(f) Weight of pure gases at standard sea level atmospheric condition of 29.92 inches Hg. pressure and 15°C temperature:

(1) Dry air = .07647 lb/ft^3.

(2) Dry helium = .01054 lb/ft^3.

(g) Unit lift - The value used should be identified in the analysis of the design. In the absence of a rational analysis, 0.0635 lb/ft^3 (96% purity) should be used for helium.

(h) Ballonet - a flexible and collapsible air cell contained within the envelope for the purpose of compensating for gas volume changes, maintaining internal pressure in the envelope, and assisting in trimming the airship.

(i) Virtual Inertia - the apparent additional inertia of a body moving in a fluid due to the motion on that fluid by the body.

1.3 Abbreviations and symbols.

The following are equivalent airspeeds (EAS) unless indicated otherwise.

(a) V_B - Design speed for maximum gust intensity.

(b) V_D - Design diving speed.

(c) V_H - Maximum level flight speed at sea level.

(d) V_{MO} - Maximum operating limit speed (Indicated airspeed-IAS)

(e) V_L - Maximum landing gear operating speed

SUBPART II - FLIGHT

General

2.1 Proof of compliance.

(a) Each of these requirements must be met at the appropriate weight and center of gravity within the range of loading conditions for which certification is requested. This must be shown by tests upon an airship of the type for which certification is requested, or by calculations based on and equal in accuracy to the results of testing.

(b) The following general tolerances are allowed during flight testing; however, greater tolerances may be allowed in particular tests:

Item	Tolerance
Weight	+5%, -10%
Critical items affected by weight	+5%, -1%
Center of gravity	±7% total travel

2.2 Load distribution limits.

Ranges of weight and centers of gravity within which the airship may be safely operated must be established.

2.3 Weight limits.

(a) Maximum weight. The maximum weight is the highest weight at which compliance with each applicable requirement of these criteria is shown. The maximum weight must be established so that it is--

(1) Not more than--

(i) The highest weight selected by the applicant;

(ii) The design maximum weight, which is the highest weight at which compliance with each applicable structural loading condition of these criteria is shown; or

(iii) The highest weight at which compliance with each applicable flight requirement is shown.

(2) Assuming a weight of 170 pounds for each occupant of each seat, not less than the weight with--

(i) Each seat occupied, oil at full tank capacity, and at least enough fuel for one-half hour of operation at rated maximum continuous power; or

(ii) The required minimum crew, and fuel and oil at full tank capacity.

(3) Not less than that which can be achieved with the car loaded to its maximum design weight.

(b) Minimum weight. The design minimum weight must be established so that it is not more than the sum of--

(1) The empty weight determined under § 2.4;

(2) The weight of the required minimum crew (assuming a weight of 170 pounds for each crewmember); and

(3) The weight of the fuel necessary for one-half hour of operation at maximum continuous power.

2.4 Empty weight and corresponding center of gravity.

(a) The empty weight and corresponding center of gravity must be determined from the weight of all items, including--

(1) The weight of the deflated envelope;

(2) Fixed ballast;

(3) Unusable fuel determined under § 5.13; and

(4) Full operating fluids, including--

(i) Oil; and

(ii) Hydraulic fluid.

* (b) The condition of the airship at the time of determining empty weight must be one that is well defined and repeatable. *

2.5 Propeller speed and pitch limits.

(a) General. The propeller speed and pitch must be limited to values that will assure safe operation under normal operating conditions.

(b) Propellers not controllable in flight. For each propeller whose pitch cannot be controlled in flight, during takeoff and initial climb at best rate of climb speed, the propeller must limit the engine r.p.m., at full throttle or at maximum allowable takeoff manifold pressure, to a speed not greater than the maximum allowable takeoff r.p.m.

(c) Controllable pitch propellers without constant speed controls. Each propeller that can be controlled in flight, but that does not have constant speed controls, must have a means to limit the pitch range so that the lowest possible pitch allows compliance with paragraph (b) of this section.

(d) Controllable pitch propellers with constant speed controls. Each controllable pitch propeller with constant speed controls must have—

(1) With the governor in operation, a means at the governor to limit the maximum engine speed to the maximum allowable takeoff r.p.m.; and

(2) With the governor inoperative, a means to limit the maximum engine speed to 103 percent of the maximum allowable takeoff r.p.m. with the propeller blades at the lowest possible pitch and with takeoff manifold pressure, the airship stationary, and no wind.

Performance

2.6 General.

(a) Unless otherwise prescribed, the performance requirements of this subpart must be met for still air and a standard atmosphere or for conditions proposed by the manufacturer if standard conditions are not applicable.

(b) The performance must correspond to the vectored, propulsive thrust available under the particular ambient atmospheric conditions.

2.7 Takeoff.

For each airship, the distance required to takeoff and climb over a 50-foot obstacle must be determined with—

(a) The airship at maximum static heaviness;

(b) The engines operating within approved operating limitations;

(c) The cowl flaps or other means for controlling the engine cooling air supply in normal takeoff position;

(d) The engines, and/or propellers, vectored, if so equipped, to each position for which takeoff approval is sought;

(e) Upon reaching a height of 50 feet above the takeoff surface, the airship must have reached the recommended climb speed; and

(f) Takeoffs made to determine the data required by this section may not require exceptional piloting skill or exceptionally favorable conditions.

2.8 Climb: all engines operating.

(a) Each airship must have a steady rate of climb at sea level of at least 300 feet per minute and a steady angle of climb of at least 1:12 with—

(1) Not more than maximum continuous power on each engine;
(2) Auxiliary thrust and lift controls in their normal position for climb;
(3) The landing gear retracted; and
(4) The cowl flaps or other means for controlling the engine cooling air supply in the position used in the cooling tests required by §§ 5.39 through 5.41.

(b) The maximum rates of ascent and descent, to be used for all operations, must be established for all conditions of equilibrium using maximum continuous forward thrust. It must be demonstrated that envelope pressures remain within the maximum and minimum approved pressures during climbs and descents at those maximum rates.

2.9 Climb: One engine inoperative.

Each multiengine airship must have a steady rate of climb at sea level of at least 100 feet per minute with—

(a) One engine inoperative and its propeller in the minimum drag position;
(b) Remaining engines at not more than maximum continuous power and most favorable settings for all auxiliary thrust and lift controls;

(c) Landing gear retracted.

(d) Cowl flaps or other means for controlling engine cooling or air supply in the position used for the engine cooling test.

2.10 Landing.

The horizontal distance necessary to land and come to a complete stop from a point 50 feet above the landing surface must be determined, with the airship in the most critical configuration for landing.

2.11 Engine failure.

The airship must be capable of rapidly restoring itself to a state of equilibrium following failure of one or more engines during any flight condition. Only designated ballast may be used.

2.12 Balked landing.

(a) Each airship must demonstrate the ability to transition to a balked landing climb from a descent and approach to landing at maximum landing weight

without excessive sink or requiring excessive pilot skill. The airship configuration will include—

(1) The ballonets trimmed for descent and landing;
(2) The landing gear extended; and
(3) Auxiliary thrust and lift controls initially in the position normally used for landing.

(b) Auxiliary thrust and lift controls may be used to assist in showing compliance to this requirement as long as they do not introduce unacceptable flying qualities or create excessive pilot workload.

Flight Characteristics

2.13 General.

The airship must meet the requirements of §§ 2.14 through 2.21 at the normally expected operating altitudes without exceptional piloting skill, alertness, or strength.

Controllability and Maneuverability

2.14 General.

(a) The airship must be safely controllable and maneuverable during—

(1) Takeoff;
(2) Climb;
(3) Level flight;
(4) Descent;
(5) Landing; and
(6) Level flight with one engine inoperative and remaining engine vectored in any allowable position.

(b) It must be shown that the airship is controllable vertically, without engine power (in the free balloon mode of flight), and that a safe descent and landing can be made.

(c) It must be possible to make a smooth transition from one flight condition to any other flight condition without exceptional piloting skill, alertness, or strength and without danger of exceeding the limit-load factor under any probable operating condition, including the sudden failure of any engine, or all engines.

(d) If, during the testing required by paragraph (c) of this section, marginal conditions exist with regard to required pilot strength, the pilot forces may not exceed the limits prescribed in the following table:

Values in pounds of force applied to the control as specified	Axis	
	Pitch	Yaw
(a) Temporary application:		
Stick	60	30
Wheel (applied to rim)	75	60
Capstan wheel	60	
Rudder pedal		150
(b) Prolonged application:		
Stick or wheel (applied to rim)	10	5
Capstan wheel	10	
Rudder pedal		20

(e) It must be possible to establish a zero rate of descent at an altitude suitable for a controlled landing following any single failure in the primary or auxiliary control systems. Control systems include mechanical and electrical devices such as:

(1) Aerodynamic surfaces
(2) Vectored thrust systems
(3) Ballast
(4) Helium/Air valves
(5) Electric or hydraulic actuator
(6) Associated wiring or hydraulic tubing
(7) Power sources
(8) Control system boost.

(f) Multiple failures should be addressed when—

(1) They might occur from a common source;
(2) The first malfunction is not announciated and would not be detected during normal operation, including periodic checks established at intervals which are consistent with the degree of hazard involved; or
(3) The first malfunction would inevitably lead to other malfunctions.

2.15 Longitudinal control.

With all engines operating at maximum continuous power, appropriate lift control settings and airship trimmed, it must be possible to produce—

(a) A nose down pitch change out of a stabilized climb with 30° nose-up deck angle; and

(b) A nose-up pitch change out of a stabilized descent with 30° nose-down deck angle.

2.16 Control during landing.

Sufficient pitch control authority must exist under normal approach and landing conditions to permit the pilot to achieve the desired attitude. The technique and limits for such control must be published in the Airship Flight Manual.

Trim

2.17 Trim.

It shall be demonstrated that the airship, when in static trim and equilibrium, can be flown in horizontal flight at all airspeeds in still air with the elevator controls approximately neutral.

Stability

2.18 Stability.

The airship must be sufficiently stable in both pitch and yaw axes in steady unaccelerated flight during ascent, descent, and level flight when trimmed at the appropriate operating speeds and with consistent use of auxiliary thrust and lift controls to ensure that the pilot will not be unduly fatigued and distracted from his normal duties.

Miscellaneous Flight Requirements

2.19 Vibration and buffeting.

Each part of the airship must be free from excessive vibration under any appropriate speed and power condition up to V_D. In addition, buffeting must not occur in any normal flight condition severe enough to interfere with the satisfactory control of the airship, cause excessive fatigue to the crew, or result in structural damage.

2.20 Envelope pressure and distortion.

It must be shown that any envelope distortion will not interfere with flight path control throughout the range of speed, power, and envelope pressure to be used in normal flight. In addition the following apply:

(a) A means must be provided for the pilot to determine and control the envelope pressure within the design pressure range.

(b) An operational procedure must be provided and must be set forth in the Airship Flight Manual.

(c) Improper use of the procedure and the controls necessary to comply with subparagraph (a) must not jeopardize the integrity of the envelope.

2.21 Ground handling characteristics.

(a) Satisfactory ground handling procedures must be developed assuming the specified minimum ground crew, all anticipated airship weight and buoyancy conditions, and wind conditions.

(b) Mooring procedures must be developed for the use of both a fixed mast and a mobile mast.

SUBPART III - STRUCTURE

General

3.1 Loads.

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

(b) Unless otherwise provided, the air and ground loads must be placed in equilibrium with inertia forces, considering each item of mass in the airship, and, where appropriate, taking into account the effects of virtual inertia of the airship.

(c) Compliance with the structural requirements must be shown at any combination of weight, from the design minimum weight to the design maximum weight and the most adverse center of gravity position within the range for which certification is sought.

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

3.2 Factors of safety.

Unless otherwise provided, a factor of safety of 1.5 must be used.

3.3 Strength and deformation.

(a) The structure must be able to support limit loads without detrimental permanent deformation. At any load up to limit loads, the deformation may not interfere with safe operation.

(b) The structure must be able to support ultimate loads without failure for at least 3 seconds. However, when proof of strength is shown by dynamic tests simulating actual load conditions, the 3 second limit does not apply.

3.4 Proof of structure.

Compliance with the strength and deformation requirements 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.

3.5 Design Weights.

The weight of the airship is equivalent to its maximum design static buoyancy plus any additional weight which may be carried by dynamic lift (distributed on the envelope and empennage in an acceptable manner) or by vectored thrust.

(a) Maximum design weight. The maximum weights at which compliance is shown with each applicable structural and flight requirement are defined below:

(1) Maximum design equilibrium weight = W_o (lb.)

(2) Maximum static heaviness = W_{sh} (lb.) The amount by which the weight of an airship exceeds the displacement buoyancy.

(3) Maximum landing weight = W_l (lb.)

(4) Maximum takeoff weight = W_t (lb.) = $W_o + W_{sh}$

(5) Maximum car weight

(b) Minimum design weight. The minimum weights at which compliance is shown with each applicable requirement are defined below:

(1) Minimum design weight = W_m (lb.)

(2) Maximum static lightness = W_{sl} (lb.) The amount by which the weight of an airship is less than the displacement buoyancy.

3.6 Design airspeeds.

The selected design airspeeds are equivalent airspeeds (EAS) except as provided in specific requirements.

(a) Design maximum level flight airspeed, V_H. V_H is the maximum speed obtainable in level flight with all engines operating at maximum continuous power and the airship loaded to equilibrium buoyancy or that loading which will produce minimum drag.

(b) Design airspeed for maximum gust intensity, V_B. V_B shall not be less than 35 knots or 0.65 V_H, whichever is least.

(c) Design dive airspeed, V_D. V_D may not be less than the greater of—

(1) V_H; or
(2) Maximum airspeed obtainable in a dive with all engines at maximum continuous power and the airship in the minimum drag configuration.

Flight Loads

3.7 General.

Compliance with the flight load requirements of this subpart must be shown-

(a) At each critical altitude within the range in which the airship may be expected to operate;

(b) At each weight from the minimum design weight to the maximum design weight; and

(c) For each required altitude and weight, at any practicable distribution of disposable load within the operating limitations specified in §§ 7.26 through 7.29.

3.8 Design maneuver loads.

(a) The airship, including control surfaces, is considered to be subjected to the loads resulting from the maneuvering conditions listed in Table 1. Steady state and transient effects during checked and unchecked maneuvers must be taken into account.

(b) Consideration of the maneuvering conditions must include the investigation of both the separate and the combined effects of the rudder and elevator controls.

TABLE 1 DESIGN MANEUVER CONDITIONS

	Condition	Speed	Weight	Attitude	Thrust Direction	Control Surface Position Rudder	Elevator
1	Level Flight	V_H	W_t	NOTE 2	Forward	Neutral	NOTE 2
2	Level Flight Reverse Thrust	$0.71V_H$	W_l	NOTE 2	Reverse	Neutral	NOTE 2
3	Nose Down	V_H	W_o	+ 30°	Forward	Neutral	NOTE 2
4	Nose Up	V_H	W_o	- 30°	-	Neutral	NOTE 2
5	Descent & Pull-Up	V_H	W_t	NOTE 2	Forward	Neutral	NOTE 2
6	Turn Entry	V_H	W_o	Horizontal	Forward	Full Over	Neutral
7	Turn & Reverse	V_H	W_o	Horizontal	Forward	NOTE 3	Neutral
8	Dive Entry	V_H	W_o	Horizontal	Forward	Neutral	Full Down
9	Climb Entry	V_H	W_o	Horizontal	Forward	Neutral	Full Up
10	Turn & Climb	V_H	W_o	Horizontal	Forward	Full Over	Full Up
11	Turn & Dive	V_H	W_o	Horizontal	Forward	Full Over	Full Down
12	Turn	Note 1	W_o	Horizontal	Forward	Full Over	Neutral
13	Turn Recovery	Note 1	W_o	Horizontal	Forward	Note 3	Neutral
14	Turn Rec. & Climb	Note 1	W_o	Horizontal	Forward	Note 3	Full Up
15	Turn Rec. & Dive	Note 1	W_o	Horizontal	Forward	Note 3	Full Down
16	Light Flight	V_H	Note 2	NOTE 2	Forward	Neutral	NOTE 2

NOTE 1 - Velocity values must be determined for a steady state condition.
NOTE 2 - That necessary to produce maximum loading conditions.
NOTE 3 - Full rudder must be applied followed by full reverse rudder after 75° of turn.

3.9 Gust loads.

(a) The airship is assumed to be subjected to the loads resulting from encounters with the following atmospheric gusts in level flight:

(1) Discrete gust of 25 f.p.s. while flying at speed, V_H.

(2) Discrete gust of 35 f.p.s. while flying at speed, V_B.

(3) Gust shapes and intensities are defined as follows:

$$U = \frac{U_m}{2}\left(1-\cos\frac{\pi X}{H}\right)$$

where--

U_m = gust velocity specified above (f.p.s.);

X = penetration distance, $0 \leq X \leq 2H$ (ft.);

H = gust gradient length, $\frac{L}{4} \leq H \leq 800$ (ft.); and

L = length of airship (ft.)

(4) The dynamic response of the airship to the design gusts as well as the steady state loads must be taken into account.

(b) The gusts are applied in any direction, including parallel to the airship axis, with the control surfaces in both the neutral position and the maximum effective angles required to counteract the gust.

(c) In the absence of a more rational analysis, the maximum aerodynamic bending moment, applied to the envelope, must be computed as follows:

* $$M = 0.029(1+[L/d - 4.0][0.5624L^{0.02} - 0.5])\rho\mu\nu\forall\sqrt[4]{L}$$

where--

L = length of airship (ft.);

d = maximum envelope diameter (ft.);

ρ = density of air (slugs/cu.ft.)

μ = gust velocity from paragraph (a)(f.p.s.);

ν = airship equivalent speed from paragraph (a)(f.p.s.);

$\forall$ = total envelope volume (cu.ft.)

This equation is applicable for L/D between 4.0 and 6.0. For L/D below 4.0, use 4.0. *

(d) The empennage is assumed to be subjected to the discrete gusts defined in paragraph (a) applied under the following conditions:

(1) The airship is in straight and level flight.

(2) The gust is applied at 90° to either set of tail surfaces.

(3) Control surfaces must be considered to be in both the neutral position and at the maximum effective angles required to counteract the gust.

(4) The effective angle of attack is assumed to be:

$$\alpha = 1.25 \tan^{-1} \frac{U_m}{1.689V}$$

(5) Control surface loads plus stern aerodynamic forces in the envelope induced by the empennage must be placed in equilibrium with opposing inertia forces in a rational or conservative manner with the airship at its maximum weight.

3.10 Engine torque.

(a) Each engine mount and its supporting structure must be designed for the effects of--

(1) A limit engine torque corresponding to takeoff power and propeller speed acting simultaneously with 75 percent of the limit loads from the design maneuver conditions of § 3.8;

(2) A limit engine torque corresponding to the maximum continuous power and propeller speed acting simultaneously with the limit loads from the design maneuver conditions of § 3.8; and

(3) For turbopropeller installations, in addition to the conditions specified in paragraph (a)(1) and (a)(2) of this section, a limit engine torque corresponding to takeoff power and propeller speed, multiplied by a factor accounting for propeller control system malfunction, including quick feathering, acting simultaneously with 1g level flight loads. In the absence of a rational analysis, a factor of 1.6 must be used.

(b) For turbine engine installations, the engine mounts and supporting structure must be designed to withstand each of the following:

(1) A limit engine torque load imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(2) A limit engine torque load imposed by the maximum acceleration of the engine.

(c) The limit engine torque, to be considered under paragraph (a) of this section, must be obtained by multiplying the mean torque by a factor of—

(1) 1.25 for turbopropeller installations, unless power transients can cause a higher limit torque.

(2) 1.33 for engines with five or more cylinders; and

(3) Two, three, or four for engines with four, three, or two cylinders, respectively.

(d) When the airflow through the propeller is not symmetrical, due to airship yawing and pitching, or engine vectoring, the additional forces must be considered.

3.11 Side load on engine mount.

(a) Each 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—

(1) 1.33, or

(2) One-third of the limit load factor for design maneuver conditions specified in § 3.8.

(b) The side load prescribed in paragraph (a) of this section may be assumed to be independent of other flight conditions.

3.12 Engine failure loads.

For turbopropeller power airships, the engine mount and support structure must be designed for the loads resulting from the failure of any one engine in combination with a single malfunction of the propeller drag-limiting system. The following conditions apply:

(a) The loads resulting from power failure because of fuel flow interruption are considered to be limit loads.

(b) The loads resulting from the disconnection of the engine compressor from the turbine or from loss of the turbine blades are considered to be ultimate loads.

3.13 Gyroscopic loads.

For turbine powered airships, each engine mount and its supporting structure must be designed for the gyroscopic loads resulting from the maneuver loads combined with the maximum rate of angular change in vectored thrust with the engines at maximum continuous r.p.m.

Control Surface and System Loads

3.14 Control surface loads.

(a) Control surfaces must be designed for the control surface loads resulting from the conditions described in §§ 3.8 and 3.9.

(b) In the flight loading conditions, the airloads on movable surfaces and the corresponding deflections need not exceed those that would result in flight from the application of any pilot force within the ranges specified in § 3.16(b). However, these pilot forces may not be less than the actual maximum pilot forces determined when complying with § 2.14(c). In applying this criterion, the effects of control system boost and servo-mechanisms, and the effects of tabs must be considered. The automatic pilot effort must be used for design if it alone can produce higher control surface loads than the human pilot.

3.15 Control system loads.

(a) Each flight control system and its supporting structure must be designed for loads corresponding to at least 125 percent of the computed hinge moments of the movable control surface in the conditions prescribed in §§ 3.8 and 3.9. However, these loads need not exceed the higher of the loads that can be produced by the pilot or by the autopilot.

(b) The system must be designed for the maximum effort of the pilot or autopilot, whichever is higher. In addition, if the pilot and the autopilot act in opposion, the part of the system between them may be designed for the maximum effort of the one that imposes the lesser load. Pilot forces used for design need not exceed the maximum forces prescribed in § 3.16(b).

(c) The design must, in any case, provide a rugged system for service use. Compliance with this paragraph may be shown by designing for loads resulting from application of the minimum forces prescribed in § 3.16(b).

3.16 Pilot forces.

(a) Pilot forces used for design are assumed to act at the appropriate control grips or pads as they would in flight, and to be reacted at the attachments of the control system to the control surface horns.

(b) The pilot forces and torques are presented in Table 2.

TABLE 2 - PILOT FORCES

Control	Maximum forces or torques	Minimum forces or torques
Elevator:		
(i) Capstan wheel (1)	167 lb.	100 lb.
(ii) Wheel mounted on a column		
(Symmetrical)	200 lb.	100 lb.
(Unsymmetrical) (2)	------	100 lb.
(iii) Stick	167 lb.	100 lb.
Rudder:		
(i) Rudder pedals	200 lb.	130 lb.
(ii) Wheel mounted on a column (3)	50D in.-lb. (4)	40D in.-lb. (4)
(iii) Stick	67 lb.	40 lb.

Notes:

(1) When a capstan wheel is mounted beside the pilot, the fore-and-aft force is applied to the highest point on the rim of the wheel.

(2) The unsymmetrical force must be applied at one of the normal hand grip points on the control wheel.

(3) When the rudder operating control is a wheel mounted on a column in front of the pilot, the loads must be applied tangentially to the rim of the wheel.

(4) D = wheel diameter (inches).

3.17 Dual control system.

(a) Each dual control system must be designed for the pilots operating in opposition, using individual pilot forces not less than—

(1) 0.75 times those obtained under § 3.14; or

(2) The minimum forces specified in § 3.16(b)

(b) The control system must be designed for pilot forces applied in the same direction, using individual pilot forces not less than 0.75 times those obtained under § 3.14.

3.18 Secondary control system.

Secondary controls, such as valve and damper controls, must be designed for the maximum forces that a pilot is likely to apply to those controls.

3.19 Trim tabs.

(a) The effects of trim tabs on the control surface design conditions must be accounted for only where the surface loads are limited by maximum pilot effort. In these cases, the tabs are considered to be deflected in the direction that would assist the pilot.

(b) Control surface tabs must be designed for the severe combination of airspeed and tab deflection likely to be obtained.

3.20 Supplementary conditions for control surfaces.

For airships with control surfaces having appreciable angles with respect to the horizontal and vertical axes or having inter surface supports, the surfaces and supporting structure must be designed for the combined surface loads prescribed for the separate systems.

3.21 Tail-to-wind loads.

(a) The control surface hinges and control system must be designed, as follows, for control surface loads due to tail-to-wind loads:

(1) In the absence of a more rational analysis, the load distribution on the movable control surface must be computed as varying linearly from zero at the hinge to a maximum value at the trailing edge.

(2) The control system, from the control surface horns to the location reacting the loads (stops, gust locks, pilot controls), must be designed for loads corresponding to the hinge moment, H, of subparagraph (3) of this paragraph.

(3) Control surface hinge moments computed from the following formula need not exceed the loads corresponding to the maximum pilot loads in § 3.16(b).

$$H = KcSq,$$

where —

H = limit hinge moment (ft.-lb.);

c = mean chord of the control surface aft of the hinge line (ft.);

S = area of the control surface aft of the hinge line (sq.ft.);

q = dynamic pressure (p.s.f.) based on a design speed of not less than 15 f.p.s.; and

K = hinge moment factor, 1.40.

(b) The resulting loads on each surface must be determined for locked and unlocked controls in positive and negative positions with the surface against the stops and in the neutral position.

Ground Loads

3.22 General.

The limit ground loads specified in this subpart are considered to be external loads that act upon the airship structure. In each specified ground load condition, the external loads must be placed in equilibrium with the linear and angular inertia forces in a rational or conservative manner.

3.23 Ground load assumptions.

(a) The ground load requirements of this subpart must be complied with at the weights and shock absorber extensions shown in Table 3.

(b) The selected limit vertical inertia load factor at the center of gravity of the airship for the landing load conditions prescribed in this subpart may not be less than that which would be obtained when landing with the maximum descent velocity expected to occur in service but may not be less than 3 feet per second. Proper consideration may be given to the distribution of the landing energy between the car and the envelope. No allowance shall be made for dynamic lift throughout the landing impact. The limit vertical inertia load factor, n, represents the ratio of the externally applied vertical forces to the weight of the airship.

(c) Energy absorption tests (to determine the limit load factor, n, corresponding to the required limit descent velocities) must be made under § 4.24(a).

3.24 Landing conditions.

The landing gear and airship structure are considered to be subjected to the loads resulting from the takeoff and landing conditions listed in Table 3. In determining the ground loads on the landing gear and affected support structure, the following apply:

(a) When investigating landing conditions, the drag components simulating the forces required to accelerate the tires and wheels up to the landing speed must be properly combined with the corresponding instantaneous vertical ground reactions assuming a tiresliding coefficient of friction of 0.8. The contact speed must be appropriate to landing the airship at the maximum anticipated forward landing speed but may not be less than 15 knots. In determining wheel spin-up loads, the method set forth in FAR 23, Appendix D, may be used.

(b) If a swivel (without lock, steering device or shimmy damper) is used, in addition to the above requirements, the gear is assumed to be swiveled 90 degrees to the airship longitudinal axis, with the resultant ground load passing through the axle.

(c) Auxiliary landing gear (e.g., wheels mounted on tail fin) must be designed to withstand the loads resulting from expected service.

TABLE 3 - TAKEOFF AND LANDING CONDITIONS

Condition	Attitude	Weight	Shock Absorber Extension	Landing Gear Loads (3)		
				Vertical	Lateral(2)	Longitudinal(2)
Takeoff	Level	W_t	static	$1.5W_{sh}$	0	$.275W_{sh}$
Level Landing	Level	W_l	Maximum	$n\ W_l$	0	$\pm.25nW_l$
Level Landing	Level	W_l	Maximum	$n\ W_l$	0	(1)
Side Drift Landing	Level	W_l	static	W_l	$.55W_l$	0

Notes:

(1) This load is based upon spin-up or spring-back conditions.

(2) Lateral and longitudinal loads act in a horizontal plane.

(3) For landing gear equipped with dual wheels, use a 60/40 load distribution between wheels.

(4) n is the limit vertical inertia load factor, at the C.G. of the airship, selected under § 3.23(b).

3.25 Mooring and handling conditions.

The limit loads specified in this section are considered to be external loads that act upon the airship structure and handling lines. These loads are those

resulting from the mooring and handling conditions listed in Table 4. For these conditions, the airship is considered in the landing configuration.

TABLE 4 - MOORING AND HANDLING CHARACTERISTICS

Condition (6)	Weight	Wind Velocity (knots)	Wind Angle (Degrees)
Symmetrical Mooring	W_t	70	0
Unsymmetrical Mooring	W_t	70	(2)
Mast Handling-Heavy (3)	W_t	(1)	(2)
Mast Handling - Equilibrium (3)	W_o	(1)	(2)
Mast Handling - Override (4)	W_t	0	0
Line Handling (3), (5)	W_t	(1)	(2)
Line Handling (3), (5)	W_o	(1)	(2)

Notes:

(1) The maximum wind velocities expected to occur during ground handling are selected by the designer and listed in the airship operating limitations, but may not be less than 10 knots.

(2) The wind angle must be determined from the lateral wind force and the longitudinal wind force assumed imposed on the envelope with maximum design gas pressure. These wind forces are based on an instantaneous directional change to either side. In the absence of a more rational analysis, a wind angle of 10 degrees must be used.

(3) An envelope of ground loads must be determined based on critical effective relative wind angles.

(4) Loads must be determined based on a compressive force between mast and airship resulting from a differential speed of 3 knots.

(5) For nose lines, use wind angles determined for mooring conditions with line angles of 0-120 degrees laterally with respect to a vertical plane through the airship axis and at an angle of 30 degrees below the horizontal plane through the airship axis. For tail or after quarter lines, an envelope of ground loads must be determined, using wind angles determined for mast handling. In the absence of a more rational analysis, use line angles of 60-120 degrees laterally to the same reference planes as for the nose lines. Line angles selected must be listed in the airship handling procedures.

(6) Compressive loads caused by elastic rebound of the airship due to a sudden change in wind velocity must be considered for all applicable mooring conditions.

Emergency Landing Conditions

3.26 General.

(a) The airship, including its propulsion system, although it may be damaged in emergency landing conditions, must be designed as prescribed in this section to protect each occupant under those conditions.

(b) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in a minor crash landing when--

(1) Proper use is made of seat belts provided for in the design; and

(2) The occupant experiences the ultimate inertia forces shown in the following table:

Ultimate Inertia Forces

Upward	0
Downward	3.0g
Forward	2.5g
Rearward	1.0g
Sideward	1.0g

(c) The supporting structure must be designed to restrain, under loads up to those specified in subparagraph (b)(2) of this section, each item of mass that could injure an occupant if it came loose in a minor crash landing.

SUBPART IV - DESIGN AND CONSTRUCTION

4.1 General.

The suitability of each questionable design detail and part having an important bearing on safety must be established by tests.

4.2 Materials and workmanship.

(a) The suitability and durability of materials used for parts, the failure of which could adversely affect safety must—

(1) Be established by experience or test;

(2) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and

(3) Take into account the effects of environmental conditions expected in service.

(b) Workmanship must be of a high standard.

4.3 Fabrication methods.

(a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process requires close control to reach this objective, the process must be performed in accordance with an approved process specification.

(b) Each new aircraft fabrication method must be substantiated by a test program.

4.4 Fastenings.

Only approved bolts, pins, screws, and rivets may be used in the structure. Approved locking devices or methods must be used for all these bolts, pins, and screws, unless the installation is shown to be free from vibration. Self-locking nuts may not be used on bolts that are subject to rotation in service.

4.5 Protection.

Each part of the airship must—

(a) Be suitably protected against deterioration or loss of strength in service due to weathering, corrosion, abrasion, or other causes; and

(b) Have adequate provisions for ventilation and drainage.

4.6 Accessibility.

Means must be provided to allow inspection, close examination, repair, and replacement of each part requiring maintenance, adjustments, lubrication or servicing.

4.7 Material strength properties and design values.

(a) Material strength properties must be based on enough tests of material meeting specifications to establish design values on a statistical basis.

(b) The design values must be chosen so that the probability of any structure being understrength because of material variations is extremely remote.

(c) Design values must be those contained in or determined from the following publications (obtainable from the Superintendent of Documents, Government Printing Office, Washington, DC 20402) or other values approved by the Administrator:

MIL-HDBK-5. "Metallic Materials and Elements for Flight Vehicle Structure";

MIL-HDBK-17, "Plastics for Flight Vehicles";

ANC-18, "Design of Wood Aircraft Structures";

MIL-HDBK-23, "Composite Construction for Flight Vehicles"; and

Federal Requirement 191-A, "Textile Test Methods".

4.8 Design properties.

(a) Design properties outlined in MIL-HDBK-5 may be used subject to the following conditions:

(1) Where applied loads are eventually distributed through a single member within an assembly, the failure of which would result in the loss of the structural integrity of the component involved, the guaranteed minimum design mechanical properties ("A" values) when listed in MIL-HDBK-5 must be met.

(2) Redundant structures in which the partial failure of individual elements would result in applied loads being safely distributed to other load carrying members may be designed on the basis of the "90 percent probability" ("B" values) when listed in MIL-HDBK-5. Examples of these items are sheet-stiffener combinations and multi-rivet or multiple-bolt connections.

(b) Design values greater than the guaranteed minimums required by paragraph (a) of this section may be used if a "premium selection" of the material is made in which a specimen of each individual item is tested before use to determine that the actual strength properties of that particular item will equal or exceed those used in design.

(c) Material correction factors for structural items such as sheets, sheet-stringer combinations, and riveted joints, may be omitted if sufficient test data are obtained to allow a probability analysis showing that 90 percent or more of the elements will equal or exceed allowable selected design values.

4.9 Special factors.

The factor of safety prescribed § 3.2 must be multiplied by the highest pertinent special factors of safety determined in §§ 4.10 through 4.12 for each part of the structure whose strength is—

(a) Uncertain;

(b) Likely to deteriorate in service before normal replacement; or

(c) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

4.10 Casting factors.

(a) General. The factors, tests, and inspections specified in paragraphs (b) through (d) of this section must be applied in addition to those necessary to establish foundry quality control. The inspections must meet approved specifications. Paragraphs (c) and (d) of this section apply to any structural castings except castings that are pressure tested as parts of hydraulic or other fluid systems and do not support structural loads.

(b) Bearing stresses and surfaces. The casting factors specified in paragraphs (c) and (d) of this section—

(1) Need not exceed 1.25 with respect to bearing stresses, regardless of the method of inspection used; and

(2) Need not be used with respect to the bearing surfaces of a part whose bearing factor is larger than the applicable casting factor.

(c) Critical castings. For each casting whose failure would preclude continued safe flight and landing of the airship or result in serious injury to occupants, the following apply:

(1) Each critical casting must—

(i) Have a casting factor of not less than 1.25; and

(ii) Receive 100 percent inspection by visual, radiographic, and magnetic particle or penetrant inspection methods or approved equivalent nondestructive inspection methods.

(2) For each critical casting with a casting factor less than 1.50, 3 sample castings must be static tested and shown to meet the strength requirements of § 3.3 at an ultimate load corresponding to a casting factor of 1.25, and the deformation requirements of § 3.3 at a load of 1.15 times the limit load.

(3) Examples of these castings are structural attachment fittings, parts of flight control systems, control surface hinges and balance weight attachments, seat, berth, safety belt, and fuel and oil tank supports and attachments, and cabin pressure valves.

(d) Noncritical castings. For each casting other than those specified in paragraph (c) of this section, the following apply:

(1) Except as provided in subparagraphs (2) and (3) of this paragraph, the casting factors and corresponding inspections must meet the following table:

Casting factor	Inspection
2.0 or more	100 percent visual
Less than 2.0 but more than 1.5.	100 percent visual, and magnetic particle or penetrant, or equivalent nondestructive inspection methods.
1.25 through 1.50	100 percent visual, magnetic particle or penetrant, and radiographic, or approved equivalent nondestructive inspection methods.

(2) The percentage of castings inspected by nonvisual methods may be reduced below that specified in subparagraph (1) of this paragraph when an approved quality control procedure is established.

(3) For castings procured to a specification that guarantees the mechanical properties of the material in the casting and provides for demonstration of these properties by test of coupons cut from the castings on a sampling basis—

(i) A casting factor of 1.0 may be used; and

(ii) The castings must be inspected as provided in subparagraph (1) of this paragraph for casting factors of "1.25 through 1.50," and tested under paragraph (c)(2) of this section.

4.11 Bearing factors.

(a) Each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) For control system joints, compliance with the factors prescribed in paragraph 4.23, meets paragraph (a) of this section.

4.12 Fitting factors.

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

(a) For each fitting whose strength is not proven by limit and ultimate load tests in which actual stress conditions are simulated in the fitting and surrounding structures, a fitting factor of at least 1.15 must be applied to each part of--

(1) The fitting;

(2) The attachment means; and

(3) The bearing on the joined members.

(b) A fitting factor is not required for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood)

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

(d) For each seat, berth, and safety belt, its attachment to the structure must be shown, by analysis, tests, or both, to be able to withstand the inertia forces prescribed in paragraph 3.26 multiplied by a fitting factor of 1.33.

Control Systems

4.13 General.

(a) Each control must operate easily, smoothly, and positively enough to allow proper performance of its functions.

(b) Controls must be arranged and identified to provide for convenience in operation and to prevent the possibility of confusion and subsequent inadvertent operation.

4.14 Primary flight controls.

(a) Primary flight controls are those used by the pilot for the immediate control of pitch and yaw.

(b) Regardless of the type of control system, the design must minimize the probability of complete loss of control in the event of failure of any connecting or transmitting element in the control system. A means must be provided the pilot to rapidly disable or disconnect the control system in the event of any malfunction and transition to the backup system where backup systems are provided.

(c) For any mechanical control system (primary or backup) installed, where envelope expansion or contraction could adversely affect control cable tension or mechanical freedom, a means must be provided to automatically adjust and maintain control cable tension or mechanical freedom.

(d) In the event that there is no direct mechanical linkage provided between the pilot's primary controls and the control surfaces, a dual redundant means of controlling those surfaces must be provided and a method for the pilot to easily and rapidly transition from the primary means of controlling those surfaces to the backup means such that no unsafe flight characteristics are encountered and the probability of complete loss of control is unlikely.

* (i) It must be shown that a fiber optic data bus installation is as reliable as a wire data bus installation for the applicable critically level of the installation. Of particular concern is the cable cyclic flexing and vibration and contamination of any junction in the optical link. *

* (ii) System performance must continue to perform its intended function during and after exposure to the required tests. *

4.15 Stops.

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

(b) Each stop must be located so that wear, slackness, or takeup adjustments will not adversely affect the control characteristics of the airship because of a change in the range of surface travel.

(c) Each stop must be able to withstand any loads corresponding to the design conditions for the control system.

4.16 Trim systems.

(a) Trim systems include ballonets, trim tabs on aerodynamic control surfaces, or any other system which directly affects the long-term, in-flight, attitude of the airship. Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim operation.

(b) When ballonets are used for trimming, the pilot must be capable of determining when they are completely empty and completely full.

(c) When trim tabs are used, there must be means near the trim control to indicate to the pilot the direction of trim control movement relative to airship 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.

(d) Tab controls must be irreversible unless the tab is properly balanced and 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 airship structure.

4.17 Control system locks.

If there is a device to lock the control system on the ground or water, there must be means to--

(a) Give unmistakable warning to the pilot when the lock is engaged; and

(b) Prevent the lock from engaging in flight.

4.18 Limit load static tests.

(a) Compliance with the limit load requirements of this part must be shown by tests in which--

(1) The direction of the test loads produces the most severe loading in the control system; and

(2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included.

(b) Compliance must be shown (by analyses or individual load tests) with the special factor requirements for control system joints subject to angular motion.

4.19 Operation tests.

(a) It must be shown by operation tests that, when the controls are operated from the pilot compartment with the system loaded as prescribed in paragraph (b) of this section, the system is free from--

(1) Jamming;

(2) Excessive friction; and

(3) Excessive deflection.

(b) The prescribed test loads are--

(1) For the entire system, loads corresponding to the limit airloads on the appropriate surface, or the limit pilot forces, whichever are less; and

(2) For secondary controls, loads not less than those corresponding to the maximum pilot effort established under § 3.18.

* (c) For nonmechanical flight control systems, it must be shown by operating tests that the airship is fully controllable following a hard-over in any axis such that no unsafe condition exists between the time the hard-over occurs, pilot recognition of the hard-over, and the time to revert to the back-up system. Furthermore, it must be shown that, following recognition time after the hard-over input, the pilot can successfully, safely transition to a manual system without exceptional pilot skill, alertness, or strength. Furthermore, the airship must be fully controllable following any single failure in the system. *

4.20 Control system details.

(a) Each detail of each control system must be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, loose objects, or the freezing of moisture.

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

(c) There must be means to prevent the rubbing of cables or tubes against other parts.

(d) 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.

4.21 Spring devices.

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.

4.22 Cable systems.

(a) Each cable, cable fitting, turnbuckle, splice, and pulley used must meet approved specifications. In addition--

(1) No cable smaller than 1/8-inch diameter may be used in primary control systems;

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

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

(b) 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.

(c) Fairleads must be installed so that they do not cause a change in cable direction of more than 3 degrees.

(d) Clevis pins subject to load or motion and retained only by cotter pins may not be used in the control system.

(e) Turnbuckles must be attached to parts having angular motion in a manner that will positively prevent binding throughout the range of travel.

(f) Tab control cables are not part of the primary control system and may be less than 1/8-inch diameter in airships that are safely controllable with the tabs in the most adverse positions.

4.23 Joints.

Control system joints (in push-pull systems) that are subject to angular motion, except those in ball and roller bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball or roller bearings, the approved ratings may not be exceeded.

Landing Gear

4.24 Shock absorption test

(a) It must be shown that the limit load factors selected for design in accordance with § 3.23(b) will not be exceeded. This must be shown by energy absorption tests except that analysis based on tests conducted on a landing gear system with identical energy absorption characteristics may be used for increases in previously approved takeoff and landing weights.

(b) The landing gear may not fail, but may yield, in the test showing its reserved energy absorption capacity, simulating a descent velocity of 1.2 times the limit descent velocity.

4.25 Landing gear extension and retraction system.

(a) General. For airships with retractable landing gear, the following apply:

(1) Each landing gear retracting mechanism and its supporting structure must be designed for maximum flight-load factors with the gear retracted and must be designed for the combination of friction, inertia, and air loads, occurring during retraction at any airspeed up to V_L, selected by the applicant; and

(2) The landing gear and retracting mechanism, including the wheel well doors, must withstand flight loads, including loads resulting from all yawing conditions specified in the Structure Subpart with the landing gear extended at any speed up to V_L.

(b) Landing gear lock. There must be positive means (other than the use of hydraulic pressure) to keep the landing gear extended.

(c) Emergency operation. For airships having retractable landing gear that cannot be extended manually, unless it can be demonstrated that a safe landing can be made with the gear retracted, there must be a means to extend the landing gear in the event of either--

(1) Any reasonably probable failure in the normal landing gear operation system; or

(2) Any reasonably probable failure in a power source that would prevent the operation of the normal landing gear operation system.

(d) Operation test. The proper functioning of the retracting mechanism must be shown by operation tests.

(e) Position indicator. If a retractable landing gear is used, there must be a landing gear position indicator (as well as necessary switches to actuate the indicator) or other means to inform the pilot that the gear is secured in the extended (or retracted) position. If switches are used, they must be located and coupled to the landing gear mechanical system in a manner that prevents an erroneous indication of either "down and locked" if the landing gear is not in the fully extended position, or of "up and locked" if the landing gear is not in the fully retracted position. The switches may be located where they are operated by the actual landing gear locking latch or device.

(f) Landing gear warning. Either of the following aural or equally effective landing gear warning devices must be provided:

(1) A device that functions continuously when one or more throttles are closed if the landing gear is not fully extended and locked. A throttle stop may not be used in place of an aural device. If there is a manual shut-off for the warning device prescribed in this paragraph, the warning system must be designed so that, when the warning has been suspended after one or more throttles are closed, subsequent retardation of any throttle to or beyond the position for normal landing approach will activate the warning device.

(2) A device that functions continuously when the landing gear is not fully extended and locked and the altitude of the airship is less than 100 feet above ground level. If the altitude sensor portion of the warning system fails, the warning system must be designed to activate until the landing gear is fully extended and locked.

4.26 Wheels.

(a) Each landing gear wheel must be approved.

(b) The maximum static load rating of each wheel may not be less than the corresponding static ground reaction with the maximum takeoff weight.

(c) The maximum limit load rating of each wheel must equal or exceed the maximum radial limit load determined under the loading conditions prescribed in § 3.22.

4.27 Tires.

(a) Each tire must be approved.

(b) Tires must be such that, when fitted to the airship wheel(s) and inflated to the recommended pressures, they will be capable of withstanding the permitted operation of the airship.

(c) If specially constructed tires are used, the wheels must be plainly and conspicuously marked to that effect. The markings must include the make, size, number of plies, and identification marking of the proper tire.

(d) Each tire installed on a retractable landing gear system must, with the maximum size of the tire type expected in service, have a clearance to surrounding structure and systems that is adequate to prevent contact between the tire and any part of the structure or system.

Personnel and Cargo Accommodations

4.28 Pilot compartment.

For each pilot compartment--

(a) The compartment and its equipment must allow each pilot to perform his duties without unreasonable concentration or fatigue;

(b) Where the flight crew are separated from the passengers by a partition, an opening or openable window or door must be provided to facilitate communication between flight crew and the passengers; and

(c) The aerodynamic controls listed in § 4.32, excluding cables and control rods, must be located with respect to the * propellers so that no part of the pilot or the controls lies in * the region between the plane of rotation of any inboard propeller and the surface generated by a line passing through the center of the propeller hub making an angle of 5° forward or aft of the plane of rotation of the propeller.

4.29 Pilot compartment view.

(a) Each pilot compartment must be free from glare and reflections that could interfere with the pilot's vision, and designed so that--

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

(2) Each pilot is protected from the elements so that moderate rain conditions do not unduly impair his view of the flight path in normal flight and while landing; and

(3) Internal fogging of the windows covered under subparagraph (a)(1) of this section can be easily cleared by each pilot unless means are provided to prevent fogging.

(b) If certification for night operation is requested, compliance with paragraph (a) of this section must be shown in night-flight tests.

4.30 Windshields and windows.

(a) Nonsplintering safety glass must be used in glass windshields and windows.

(b) The windshield and windows forward of the pilot's back when seated in the normal flight position must have a luminous transmittance value of not less than 70 percent.

4.31 Cockpit controls.

(a) Each cockpit control must be located and (except where its function is obvious) identified to provide convenient operation and to prevent confusion and inadvertent operation.

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

(c) Identical powerplant controls for each engine must be located to prevent confusion as to the engines they control, and must be arranged from left to right in the following order:

(i) Throttles or power levers

(ii) Propeller pitch controls

(iii) Mixtures of fuel control/cutoff

(d) The landing gear control must be located to the left of the throttle centerline or pedestal centerline.

(e) Each fuel feed selector control must be located and arranged so that the pilot can see and reach it without moving any seat or primary flight control when his seat is at any position in which it can be placed.

4.32 Motion and effect of cockpit controls.

Cockpit controls must be designed so that they operate as follows:

Controls	Motion and effect
Aerodynamic:	
Elevator	Rearward for nose up
Rudder	Right pedal forward for nose right, or, for wheel control, right (clockwise) for right rudder.
Powerplant:	
Throttle	Forward to open.

Wherever practicable, the sense of motion involved in the operation of other controls must correspond to the sense of the effect of the operation upon the airship or upon the part operated.

4.33 Doors.

(a) Each closed cabin with passenger accommodations must have at least one adequate and easily accessible external door.

(b) No passenger door may be located with respect to any propeller disc so as to endanger persons using that door.

4.34 Seats, berths, and safety belts.

(a) Each seat, berth, and its supporting structure must be designed for occupants weighing at least 170 pounds and for the maximum load factors corresponding to the specified flight and ground load conditions, including emergency landing conditions.

(b) Each seat, berth, and safety belt must be approved.

(c) Each pilot seat must be designed for the reactions resulting from the application of pilot forces to the primary flight controls.

(d) Each berth installed parallel to the longitudinal axis of the airship must be designed so that the forward part has a padded end-board, canvas diaphragm, or equivalent means that can withstand the static load reaction of the occupant when the occupant is subjected to the forward inertia forces prescribed in § 3.26. In addition—

(1) Each berth must have an approved safety belt and may not have corners or other parts likely to cause serious injury to a person occupying it during emergency conditions; and

(2) Safety belt attachments for the berth must be designed to withstand the critical loads resulting from relevant flight and ground load conditions and from the emergency landing conditions, with the exception of the forward load.

(e) Proof of compliance with the strength and deformation requirements of this section for seats, berths, and safety belts, approved as part of the type design and for their installation, may be shown by—

(1) Structural analysis, if the structure conforms to conventional aircraft types for which existing methods of analysis are known to be reliable;

(2) A combination of structural analysis and static load tests to limit loads; or

(3) Static load tests to ultimate loads.

(f) Each occupant must be protected from serious injury when he experiences the inertia forces prescribed in § 3.26 by a safety belt for each seat.

(g) There must be a means to secure each safety belt, when not in use, so as to prevent interference with the operation of the airship and with rapid egress in an emergency.

(h) The cabin area surrounding each seat, including the structure, interior walls, instrument panel, control wheel, pedals, and seats, within striking distance of the occupant's head or torso (with the safety belt fastened), must be free of potentially injurious objects, sharp edges, protuberances, and hard surfaces. If energy absorbing designs or devices are used to meet this requirement, they must protect the occupant from serious injury when the occupant experiences the ultimate inertia forces prescribed in § 3.26.

(i) Each seat track must be fitted with stops to prevent the seat from sliding off the track.

4.35 Cargo compartments.

Each cargo compartment—

(a) Must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum-load-factors corresponding to the flight and ground load conditions of these requirements.

(b) Must contain provisions to prevent the contents of any cargo from becoming a hazard by shifting and to protect any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operations.

(c) Must be constructed of materials which are at least flame resistant.

(d) Designed to provide for cargo to be carried in the same compartment or adjacent to the compartment with the occupants, must have means to protect the occupants from injury under the ultimate inertia forces specified in § 3.26.

(e) Where lamps are installed, each lamp must be installed so as to prevent contact between lamp bulb and cargo.

(f) Not accessible to the crew while in flight must have provisions to contain a fire to allow continued safe flight and landing.

4.36 Emergency exits.

(a) Number and location. Emergency exits must be located to allow escape without crowding in any probable crash attitude. The airship must have at least the following emergency exits:

(1) For all airships, except those with all engines mounted on the approximate centerline of the car that have a seating capacity of five or less, at least one emergency exit on the opposite side of the cabin from the main door specified in § 4.33.

(2) If the pilot compartment is separated from the passenger compartment with a door that is likely to block the pilot's escape in a minor crash, there must be an exit in the pilot's compartment. The number of exits required by subparagrah (1) must then be separately determined for the passenger compartment, using the seating capacity of that compartment.

(b) Type and operation. Emergency exits must be movable windows, panels, or external doors, that provide a clear and unobstructed opening large enough to admit a 19-by-26-inch ellipse. In addition, each emergency exit must--

(1) Be readily accessible, requiring no exceptional agility when used in emergencies;

(2) Have a method of opening that is simple and obvious;

(3) Be arranged and marked for easy location and operation, even in darkness; and

(4) Have reasonable provisions against jamming by car deformation.

(c) The proper function of each emergency exit must be shown by tests.

4.37 [Reserved].

4.38 Ventilation.

All passenger and flightcrew accommodations must be suitably ventilated.

(a) Carbon monoxide concentration may not exceed one part in 20,000 parts of air.

(b) Fuel vapor may not be present in hazardous concentrations.

Fire Protection/Lightning

4.39 Compartment interiors.

For each compartment to be used by the crew or passengers, the following apply:

(a) The materials must be at least flame-resistant.

(b) Provide at least one approved and appropriately placarded handheld fire extinguisher.

(c) If smoking is prohibited, there must be a placard stating this, and if smoking is allowed:

(1) There must be an adequate number of self-contained removable ashtrays; and

(2) Where the crew compartment is separated from the passenger compartment, there must be at least one illuminated sign (using either letters or symbols) notifying all passengers when smoking is prohibited. Signs which notify when smoking is prohibited must—

(i) When illuminated, be legible to each passenger seated in the passenger cabin under all probable lighting conditions; and

(ii) Be constructed so that the crew can turn the illumination on and off.

(d) Lines, tanks, or equipment containing fuel, oil, or other flammable fluids may not be installed in such compartments unless adequately shielded, isolated, or otherwise protected so that any breakage or failure of such an item would not create a hazard.

(e) Materials located on the cabin side of the firewall must be self-extinguishing or be located at such a distance from the firewall, or otherwise protected so that ignition will not occur if the firewall is subject to a flame temperature of not less than 2,000 degrees F for 15 minutes. For self-extinguishing materials (except electrical wire and cable insulation and small parts that the Administrator finds would not contribute significantly to the propagation of a fire), a vertical self-extinguishing test must be conducted in accordance with Appendix F of Part 23 of the FAR or an equivalent method approved by the Administrator. The average burn length of the material may not exceed 6 inches and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the material test specimen may not continue to flame for more than an average of 3 seconds after falling.

4.40 Flammable fluid fire protection.

(a) In each area where flammable fluids or vapors might escape by leakage of a fluid system, there must be means to minimize the probability of ignition of the fluids and vapors, and the resultant hazard if ignition does occur.

(b) Compliance with paragraph (a) of this section must be shown by analysis or tests, and the following factors must be considered:

(1) Possible sources and paths of fluid leakage, and means of detecting leakage.

(2) Flammability characteristics of fluids, including effects of any combustible or absorbing materials.

(3) Possible ignition sources, including electrical faults, overheating of equipment, and malfunctioning of protective devices.

(4) Means available for controlling or extinguishing a fire, such as stopping flow of fluids, shutting down equipment, fireproof containment, or use of extinguishing agents.

(5) Ability of airship components that are critical to safety of flight to withstand fire and heat.

(c) If action by the flight crew is required to prevent or counteract a fluid fire (e.g., equipment shutdown or actuation of a fire extinguisher), quick acting means must be provided to alert the crew.

(d) Each area where flammable fluids or vapors might escape by leakage of a fluid system must be identified and defined.

4.41 Fire protection of flight controls and other flight structure.

Flight controls, engine mounts, and other flight structure located in the engine compartment must be constructed of fireproof material or shielded so that they will withstand the effect of the fire.

4.42 Electrical bonding and lightning discharge protection.

(a) The airship must be protected against catastrophic effects from lightning. All items, which by the accumulation and discharge of static charges may cause a danger of electric shock, ignition of flammable vapors, or interference with essential equipment, must be adequately bonded to the main ground system.

(b) Provisions must be made to minimize damage to the airship structure and to avoid injury to occupants in the case of lightning strikes either while on the ground or in flight.

Envelope

4.43 Envelope design.

(a) The envelope must be designed to be pressurized and maintain sufficient superpressure (amount of envelope pressure in excess of ambient pressure) to remain in tension while supporting * the limit design loads for all flight conditions and ground conditions, except for mooring and handling conditions, where wrinkling at the ends of the battens is permitted. The effects * of all local aerodynamic pressures (including thrust slipstream impingement) and pitch angles must be included in the determination of stresses to arrive at the limit-strength requirements for the envelope fabric.

(b) The envelope fabric must have an ultimate strength not less than four times the limit load determined by the maximum design internal pressure combined with the maximum load resulting from any of the requirements specified herein.

(c) Suspension system components made of fabric or nonmetallic material must have an ultimate strength of not less than four times the prescribed limit loads.

(d) It must be demonstrated by test in accordance with Appendix A that the envelope fabric (in both the warp and woof (fill) directions) can withstand limit design loads without further tearing.

(e) Ballonets must be designed and installed such that their center of displacement must coincide longitudinally with the center of buoyancy of the envelope. The ballonet system must be designed so that the static trim capabilities of the system about the center of buoyancy of the airship are equally divided between the fore and aft ballonets. The effective trim capabilities of the ballonets must be maintained approximately equal between the limits of 0 to 100 percent ballonet fullness. Sufficient means must be provided to prevent trapping of air when partially deflated.

(f) Provisions must be provided to permit rapid envelope deflation should the airship break away from the mast during mooring. If the airship is to be left unattended, automatic deflation must be provided. The system must be protected against inadvertent use, and must be properly identified and available to crewmembers.

* (g) A means must be provided to permit emergency deflation of the envelope on the ground during emergency evacuation of the occupants. Normal valving of helium may be considered in meeting this requirement. During evacuation, the airship must not leave the ground to an extent that would prevent occupants leaving the airship, and the envelope must not deflate at a rate that would permit the envelope to entrap the occupants. *

(h) Internal and/or external suspension systems for supporting components such as the car must be designed to transmit and distribute the resulting loads to the envelope in a uniform manner for all flight conditions. The fabric parts of such systems and their connection with the envelope must be designed and

constructed in such a manner that the bonds are not subjected to peeling loads. Provisions must be incorporated to prevent chafing between suspension system components and air system components. Suspension system cables must be adjustable as may be necessary to ensure proper load distribution.

(i) The nose of the envelope must be designed to prevent wrinkling due to high speed flight or from limit-mooring loads.

4.44 Pressure system.

A means shall be provided to control the internal pressure of the envelope and to provide air to the ballonets and must contain at least the following components:

(a) Helium Valve(s). At least one valve must be provided. The valve(s) may be located either on or near the envelope but * not higher than 10 degrees above the equator. They must be designed for both manual and automatic operation, be operable at specified pressure settings at all attainable air speeds, and be * designed to open and close positively. The valve(s) must not discharge helium into the car interior, the engine intake system, or the ballonets. The valve(s) must be of sufficient capacity to permit ascent above pressure height at the maximum design rate-of-climb without exceeding helium pressure of 1.25 times maximum operating pressure.

(b) Air Valves. At least one air valve must be provided to discharge air from each ballonet. The valves may be located in the envelope or connected to it by a suitable duct. The valve(s) must be capable of manual and automatic operation and be capable of operating at appropriate pressure settings at all attainable air speeds and must be designed to open and close positively. The valve(s) must be of sufficient capacity to permit ascent below pressure height at the maximum design rate-of-climb without exceeding helium pressure of 1.15 times maximum operating pressure.

(c) Ballonet Air Induction System. Scoops, ducts, blowers, or combinations of these must be of sufficient capacity to permit descent at the maximum design rate, without a reduction in envelope pressure below the specified design value. On multiengine airships, where ballonet pressurization is dependent upon the engines, means must be provided to pressure all ballonets during a single-engine failure.

(d) Air supply source. A reliable means of supplying air to the ballonet, must be provided, and must have adequate capacity to enable the pressure in the envelope to be maintained during flight at low engine powers and forward speeds, and, if appropriate, when thrust vectoring reduces the effectiveness of

* the engines in supplying air. The means shall also be able to maintain envelope shape to permit operation of systems dependent upon that shape following the failure of all engines for a sufficient time to permit a landing to be made. *

(e) Provisions must be made to blow air into the helium space to supplement the ballonet in case of excessive helium loss. The control(s) for this system must be readily accessible and quickly operable by the crew. A helium pressure sufficient to prevent wrinkling of the envelope at a forward speed of $0.25V_H$ must be maintained with a descent rate of 5 ft./sec.

4.45 Ground handling.

Provisions for ground handling must be provided. Handling lines must be manufactured of nonconducting materials. All fabric patches and fittings of ground handling lines must be designed with a breaking strength which exceeds the specified breaking strength of the attached cable or line assembly strength by a * minimum of 15 percent. *

4.46 Flutter.

The envelope and all fixed and movable control surfaces must be shown to be free from flutter, by analysis or flight test, at all speeds up to the maximum airspeed attained from the airship speed plus head-on gusts in accordance with § 3.9, the mooring wind speeds, or V_D, whichever is greater.

4.47 [Reserved].

Miscellaneous

4.48 Lifting gas.

The lifting gas must be non-flammable.

4.49 Ballast system.

(a) General. The ballast system, including all controls and related components, must be designed and installed so as to ensure positive, controlled disposal of the ballast by the pilot under all normal operating conditions.

(b) Capacity. The airship must contain sufficient ballast capacity, when used with other provisions, to restore itself to a condition of equilibrium at any time during normal flight operations. Adequate provisions for safe storage of the ballast under all design loading conditions must be provided.

(c) Ballast material. Ballast may be in the form of water or other disposable material such as sand or shot. It must be easily dissipated without causing injury to persons or property on the ground. If water is used, means must be provided to prevent freezing.

(d) Discharge rate. Means must be provided to discharge liquid ballast at a rate not less than 100 gallons per minute. Ballast tank vents must be installed to accommodate this discharge rate. Leakage from the tank or vents is not permitted in normal flight attitudes. The liquid discharge value must be designed to allow the crew to close the valve during any part of the discharge operation.

(e) Location of ballast ports. The ballast discharge ports or vents must not be located in the immediate vicinity of the engines, air scoops, or so as to cause impingement on the airship.

(f) Controls and instruments. Controls and instruments necessary for controlled release of the ballast by the pilot must be provided. Such controls and instruments shall be located and arranged so that they may be operated by the pilot in the correct manner without undue concentration or fatigue. If electrically actuated dump valves are used, a mechanical backup system must be provided.

4.50 Leveling means.

There must be means for determining when the airship is in a level position on the ground.

SUBPART V - POWERPLANT

General

5.1 Installation.

(a) For the purpose of these criteria, airship powerplant installations include each component that—

(1) Is necessary for propulsion; and

(2) Affects the safety and control of the major propulsion unit(s).

(b) Each powerplant must be constructed, arranged, and installed to—

(1) Ensure safe operation to the maximum altitude for which approval is requested; and

(2) Be accessible for necessary inspections and maintenance.

(c) Engine cowls and nacelles must be easily removable or openable by the pilot to provide adequate access to and exposure of the engine compartment for preflight checks.

(d) The installation must comply with—

(1) The installation instructions provided under § 33.5 of the FAR; and

(2) The applicable provisions of this subpart.

5.2 Engines.

(a) Engine type certificate.

(1) Each engine must be approved and either—

(i) Have a type certificate; or

(ii) Be certificated as a part of the airship. FAR Part 33 may be used as a guide for the certification basis.

(2) Each turbine engine must either—

(i) Comply with § 33.77 of the FAR in effect on October 31, 1974, or as later amended; or

(ii) Be shown to have a foreign object ingestion service history in similar installation locations that has not resulted in any unsafe condition.

(b) Turbine engine installations. For turbine engine installations—

(1) Design precautions must be taken to minimize the hazards to the airship in the event of an engine-rotor failure or of a fire originating inside the engine which burns through the engine case.

(2) The powerplant systems associated with engine control devices, systems, and instrumentation must be designed to give reasonable assurance that those operating limitations that adversely affect turbine rotor structural integrity will not be exceeded in service.

(c) The powerplants must be arranged and isolated from each other to allow operation, in at least one configuration, so that the failure or malfunction of any engine, or the failure or malfunction (including destruction by fire in the engine compartment) of any system that can affect an engine (other than a fuel tank if only one fuel tank is installed), will not—

(1) Prevent the continued safe operation of the remaining engines; or

(2) Require immediate action by the crewmember for continued safe operation of the remaining engines.

(d) Starting and stopping (piston engine). The design of the installation must be such that risk of fire or mechanical damage to the engine or airship, as a result of starting is reduced to a minimum. Any techniques and associated limitations for engine starting must be established and included in the Airship Flight Manual, approved manual material, or applicable operating placards. Means must be provided for stopping and restarting each engine in flight.

(e) Starting and stopping (turbine engine.) Turbine engine installations must comply with the following:

(1) The design of the installation must be such that risk of fire or mechanical damage to the engine or the airship as a result of starting the engine is reduced to a minimum. Any techniques and associated limitations must be established and included in the Airship Flight Manual, approved manual material, or applicable operating placards.

(2) Means must be provided for stopping combustion and rotation of any engine. All those components provided for compliance with this requirement, which are within any engine compartment, on the engine side of the firewall, must be at least fire resistant.

(3) It must be possible to restart an engine in flight. Any techniques and associated limitations must be established and included in the Airship Flight Manual, approved manual material, or applicable operating placards.

(4) It must be demonstrated in flight that when restarting engines following a false start, all fuel or vapor is discharged in such a way that it does not constitute a fire hazard.

(f) Restart capability. An altitude and airspeed envelope must be established for the airship for in-flight engine restarting, and each installed engine must have a restart capability within that envelope.

'5.3 Propellers.

(a) General.

(1) Each propeller must be approved and either—

(i) Have a type certificate; or

(ii) Be certificated as a part of the airship. FAR Part 35 will normally be used as a guide for the certification basis.

(2) Engine power and propeller shaft rotational speed may not exceed the limits for which the propeller is certificated.

(3) Each featherable propeller must have a means to unfeather it in flight.

(b) Propeller vibration. Each propeller and/or shroud with metal blades or highly stressed metal components must be shown to have vibration stresses, in normal operating conditions, that do not exceed values shown by the propeller manufacturer to be safe for continuous operation. This must be shown by—

(1) Measurement of stresses through direct testing of the propeller and shroud through all anticipated mission configurations.

(2) Comparison with similar installations for which these measurement have been made; or

(3) Any other acceptable test method or service experience that proves the safety of the installation. In addition—

(4) Proof of safe vibration characteristics for any type of propeller, must be shown where necessary.

(c) Propeller and/or shroud clearance.

(1) Ground clearance.

(i) Propellers. Unless smaller clearances are substantiated, propeller clearances with the airship at maximum weight and with the most adverse center of gravity may not be less than 9 inches with the ground with the airship in the level, normal takeoff, normal landing or taxiing attitude, whichever is most critical. In addition, the propellers must have positive

ground clearance in the takeoff attitude with the critical tire completely deflated and the corresponding shock strut bottomed.

(ii) Shrouds. The shrouds must have positive ground clearance in the takeoff attitude with the critical tire completely deflated and the corresponding shock strut bottomed.

(iii) Propeller to shroud clearance. Propellers must have positive clearance from shrouds under all flight and ground conditions specified in these Design Criteria.

(2) Structural clearance. There must be—

(i) At least one-half inch longitudinal clearance between the propeller blades or cuffs and stationary parts of the airship;

(ii) Positive clearance between other rotating parts of the propeller or spinner and stationary parts of the airship.

(iii) Sufficient clearance between the propeller and the envelope so as to minimize damage from debris or ice thrown by the propellers. There must be a clearance of at least 2 feet unless propeller shrouds or equivalent protective means are provided.

(3) Hazards from propeller and shroud interference for minor crash landings must be considered in the design.

5.4 Engine installation ice protection.

Propeller (except wooden propellers) and other components of complete engine installations must be protected against the accumulation of ice as necessary to enable satisfactory functioning without appreciable loss of power when operated in the icing conditions for which certification is requested. For airships, where the envelope is not protected from ice being thrown from the propellers, anti-icing devices rather than deicing devices must be used.

5.5 Turbosuperchargers.

(a) Each turbosupercharger must be approved under the engine type certificate, or it must be shown that the turbosupercharger system—

(1) Can withstand, without defect, an endurance test of 150 hours that meets the applicable requirements of § 33.49 of the FAR; and

(2) Will have no adverse effect upon the engine.

(b) Control system malfunctions, vibrations, and abnormal speeds and temperatures expected in service may not damage the turbosupercharger compressor or turbine.

(c) Each tubrosupercharger case must be able to contain fragments of a compressor or turbine that fails at the highest speed that is obtainable with normal speed control devices inoperative.

5.6 Turbopropeller-drag limiting systems.

Turbopropeller-powered airship propeller-drag limiting systems must be designed so that no single failure or malfunction of any of the systems during normal or emergency operation results in propeller drag in excess of that for which the engine mount and support structure were designed under the structural requirements of this criteria. Failure of structural elements of the drag limiting systems need not be considered if the probability of this kind of failure is extremely remote.

5.7 Powerplant operating characteristics.

(a) Turbine engine powerplant operating characteristics must be investigated in flight to determine that no adverse characteristics (such as stall, surge, or flameout) are present, to a hazardous degree, during normal and emergency operations within the range of operating limitations of the airship and of the engine.

(b) The vibration characteristics of turbine engine components whose failure could be catastrophic may not be adversely affected during normal operation.

Fuel System

5.8 General.

(a) 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 each likely operating condition, including any maneuver for which certification is requested.

(b) Each fuel system must be arranged so that—

(1) No fuel pump can draw fuel from more than one tank at a time; or

(2) There are means to prevent introducing air into the system.

5.9 Fuel system independence.

(a) Each fuel system for a multiengine airship must be arranged so that, in at least one system configuration, the failure of any one component (other than a fuel tank) will not result in the loss of power of more than one engine or require immediate action by the pilot to prevent the loss of power of more than one engine.

(b) If a single fuel tank (or series of fuel tanks interconnected to function as a single fuel tank) is used on a multiengine airship, the following must be provided:

(1) Independent tank outlets for each engine, each incorporating a shut-off valve at the tank. This shut-off valve may also serve as the fire wall shut-off valve required if the line between the valve and the engine compartment does not contain more than one quart of fuel (or any greater amount shown to be safe) that can drain into the engine compartment.

(2) At least two vents arranged to minimize the probability of both vents becoming obstructed simultaneously.

(3) Filler caps designed to minimize the probability of incorrect installation or inflight loss.

(4) A fuel system in which those parts of the system from each tank outlet to any engine are independent of each part of the system supplying fuel to any other engine.

5.10 Fuel system lightning protection.

The fuel system must be designed and arranged to prevent the ignition of fuel vapor within the system by—

(a) Direct lightning strikes to areas having a high probability of stroke attachment:

(b) Swept lightning strokes on areas where swept strokes are highly probable; and

(c) Corona or streamering at fuel vent outlets.

5.11 Fuel Flow

(a) General. The ability of the fuel system to provide fuel at the rates specified in this section and at a pressure sufficient for proper engine operation must be shown in the attitude that is most critical with respect to fuel feed and quantity of unusable fuel. These conditions may be simulated in a suitable mockup. In addition—

(1) The quantity of fuel in the tank may not exceed the amount established as the unusable fuel supply for that tank under § 5.13 plus that necessary to show compliance with this paragraph; and

(2) If there is a fuel flowmeter, it must be blocked during the flow test, and the fuel must flow through the meter bypass.

(b) Gravity systems. The minimum fuel-flow rate for gravity systems (main and reserve supply) must be 150 percent of the fuel-flow rate of the engine at the maximum power approved for takeoff under these criteria.

(c) Pump systems. The minimum fuel-flow rate for each pump system (main and reserve supply) for each reciprocating engine, must be 125 percent of the fuel flow rate of the engine at the maximum power approved for takeoff under these criteria.

(1) This flow rate is required for each main pump and each emergency pump, and must be available when the pump is running as it would during takeoff; and

(2) For each hand-operated pump, this rate must occur at not more than 60 complete cycles (120 single strokes) per minute.

(d) Auxiliary fuel systems and fuel transfer systems. Paragraph (b), (c), and (f) of this section apply to each auxiliary and transfer system, except that—

(1) The required fuel-flow rate must be established upon the basis of maximum continuous power and engine rotational speed, instead of takeoff power and fuel consumption; and

(2) A lesser flow rate may be used for a small, auxiliary tank feeding into a large, main tank, if there is a suitable placard stating that the auxiliary tank is not to be opened to the main tank unless a predetermined amount of fuel remains in the main tank.

(e) Multiple fuel tanks. If a reciprocating engine can be supplied with fuel from more than one tank, it must be possible, in level flight, to restart that engine after switching to any full tank after engine stopping, due to fuel depletion, while the engine is being supplied from any other tank.

(f) Turbine engine fuel systems.

(1) Each turbine engine fuel system must provide at least 100 percent of the fuel flow required by the engine under each intended operation condition and maneuver. The conditions may be simulated in a suitable mockup. This flow must be shown with the airship in the most adverse fuel-feed condition (with respect to altitudes, attitudes, and other conditions) that is expected in operation.

(2) If a turbine engine can be supplied with fuel from more than 1 tank, it must be possible, in level flight, to restart that engine after switching to any full tank after engine stopping, due to fuel depletion, while the engine is being supplied from any other tank.

5.12 Flow between interconnected tanks.

It must be impossible, in a gravity-feed system with interconnected tank outlets, for enough fuel to flow between the tanks to cause an overflow of fuel from any tank vent under the conditions in § 5.13, except that full tanks must be used.

5.13 Unusable fuel supply.

The unusable fuel supply for each tank must be established as not less than that quantity at which the first evidence of malfunctioning occurs under the most adverse fuel-feed condition occurring under each intended operation and flight maneuver involving that tank.

5.14 Fuel system hot weather operation.

Each fuel system must be free from vapor lock when using fuel at a temperature of 110° F under critical operating conditions.

5.15 Fuel tanks: general

(a) Each fuel tank must be able to withstand, without failure, the vibration, inertia, fluid, and structural loads that it may be subjected to in operation.

(b) Each flexible fuel tank liner must be of an acceptable kind.

(c) Each integral fuel tank must have adequate facilities for interior inspection and repair.

(d) The total usable capacity of the fuel tanks must be enough for at least one-half hour of operation at maximum continuous power.

(e) Each fuel-quantity indicator must be adjusted to account for the unusable-fuel supply determined under § 5.13.

5.16 Fuel tank tests.

(a) Each fuel tank must be able to withstand the following pressures without failure or leakage:

(1) For each conventional metal tank and nonmetallic tank with walls not supported by the airship structure, a pressure of 3.5 psi, or that pressure developed during maximum ultimate acceleration with a full tank, whichever is greater.

(2) For each integral tank, the pressure developed during the maximum limit acceleration of the airship with a full tank, with simultaneous application of the critical limit structural loads.

(3) For each nonmetallic tank with walls supported by the airship structure and constructed in an acceptable manner using acceptable basic tank material, and with actual or simulated support conditions, a pressure of 2 psi for the first tank of a specific design. The supporting structure must be designed for the critical loads occurring in the flight or landing conditions combined with the fuel-pressure loads resulting from the corresponding accelerations.

(b) Each fuel tank with large, unsupported, or unstiffened flat areas must be able to withstand the following tests without leakage or failure:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation.

(2) Except as specified in subparagraph (4) of this paragraph, the tank assembly must be vibrated for 25 hours at an amplitude of not less than 1/32 of an inch (unless another amplitude is substantiated) while 2/3 filled with water or other suitable test fluid.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any r.p.m. within the normal operating range of engine speeds is critical, the test frequency of vibration, in number of cycles per minute, must be the number obtained by multiplying the maximum continuous engine speed (r.p.m.) by 0.9.

(ii) If only one frequency of vibration resulting from any r.p.m. within the normal operating range of engine speeds is critical, that frequency of vibration must be the test frequency.

(iii) If more than one frequency of vibration resulting from any r.p.m. within the normal operating range of engine speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under subparagraph (3)(ii) and (iii) of this paragraph, the time of test must be adjusted to accomplish the same number of vibration cycles that would be accomplished in 25 hours at the frequency specified in subparagraph (3)(i) of this paragraph.

(5) During the test, the tank assembly must be rocked at a rate of 16 to 20 complete cycles per minute, through an angle of 15 degrees on either side of the horizontal (30 degrees total), about an axis parallel to the axis of the car, for 25 hours.

(c) Each integral tank using methods of construction and sealing not previously proven to be adequate by test data or service experience must be able to withstand the vibration test specified in subparagraphs (1) through (4) of paragraph (b).

(d) Each tank with a nonmetallic liner must be subjected to the sloshing test outline in subparagraph (b)(5) of this section, with the fuel at room

temperature. In addition, a specimen liner of the same basic construction as that to be used in the airship must, when installed in a suitable test tank, withstand the sloshing test with fuel at a temperature of 110°F.

5.17 Fuel tank installation.

(a) Each fuel tank must be supported so that tank loads are not concentrated. In addition—

(1) There must be pads, if necessary, to prevent chafing between each tank and its supports;

(2) Padding must be nonabsorbent, or treated to prevent the absorption of fuel;

(3) If a flexible tank liner is used, it must be supported so that it is not required to withstand fluid loads;

(4) Interior surfaces adjacent to the liner must be smooth and free from projections that could cause wear of the liner, unless—

(i) Provisions are made for protection of the liner at those points; or

(ii) The liner construction itself provides such protection;

(5) A positive pressure must be maintained within the vapor space of each bladder cell under all conditions of operation except for a particular condition for which it is shown that a zero or negative pressure will not cause the bladder cell to collapse; and

(6) Siphoning of fuel (other than minor spillage) or collapse of bladder fuel cells may not result from improper securing or loss of the fuel filler cap.

(b) Each tank compartment must be ventilated and drained to prevent the accumulation of flammable fluids or vapors. Each compartment adjacent to a tank that is an integral part of the airship structure must also be ventilated and drained.

(c) No fuel tank may be on the engine side of the firewall. There must be at least one-half inch of clearance between the fuel tank and the firewall. No part of the engine nacelle skin that lies immediately behind a major air opening from the engine compartment may act as the wall of an integral tank.

(d) If a fuel tank is installed in the personnel compartment, it must be isolated by fume and fuel-proof enclosures that are drained and vented to the exterior of the car. A bladder-type fuel cell, if used, must have a retaining shell at least equivalent to a metal fuel tank in structural integrity.

(e) Fuel tanks must be designed, located, and installed so as to retain fuel—

(1) Under the inertia forces prescribed for the emergency landing conditions in § 3.26; and

(2) Under conditions likely to occur when the airship lands either with its landing gear retracted, or when one landing gear is collapsed.

5.18 Fuel tank expansion space.

Each fuel tank must have an expansion space of not less than 2 percent of the tank capacity unless the tank vent discharges clear of the airship. It must be impossible to fill the expansion space inadvertently with the airship in the normal ground attitude.

5.19 Fuel tank sump.

(a) Each fuel tank must have a drainable sump with an effective capacity, in the normal ground and flight attitudes, of 0.25 percent of the tank capacity, or 1/16 gallon, whichever is greater, unless—

(1) The fuel system has a sediment bowl or chamber that is accessible for drainage and has a capacity of 1 ounce for every 20 gallons of fuel tank capacity; and

(2) Each fuel tank outlet is located so that, in the normal ground attitude, water will drain from all parts of the tank to the sediment bowl or chamber.

(b) Each sump, sediment bowl, and sediment chamber drain required by paragraph (a) of this section must comply with the drain provisions of § 5.29(b).

5.20 Fuel tank filler connection.

(a) Each fuel tank filler connection must be marked as prescribed in § 7.21(c).

(b) Spilled fuel must be prevented from entering the fuel tank compartment or any part of the airship other than the tank itself.

(c) Each filler cap must provide a fuel-tight seal for the main filler opening. However, there may be small openings in the fuel tank cap for venting purposes or for the purpose of allowing passage of a fuel gauge through the cap, providing water cannot enter the tank.

(d) Each fuel-filling point, except pressure fueling connection points, must have a provision for electrically bonding the airship to ground fueling equipment.

5.21 Fuel tank vents and carburetor vapor vents.

(a) Each fuel tank must be vented from the top part of the expansion space. In addition—

(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;

(2) Each vent must be constructed to prevent siphoning of fuel during normal operation;

(3) The venting capacity must allow the rapid relief of excessive differences of pressure between the interior and exterior of the tank;

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no undrainable points in any vent line where moisture can accumulate with the airship in either the ground or level flight attitudes; and

(6) No vent may terminate at a point where the discharge of fuel from the vent outlet will constitute a fire hazard or from which fumes may enter personnel compartments.

(b) Each carburetor with vapor elimination connections and each fuel injection engine employing vapor return provisions must have a separate vent line to lead vapors back to the top of a fuel tank. If there is more than one fuel tank, and it is necessary to use these tanks in a definite sequence for any reason, the vapor vent return line must lead back to the fuel tank to be used first, unless the relative capacities of the tanks are such that return to another tank is preferable.

5.22 Fuel tank outlet.

(a) There must be a fuel strainer for the fuel tank outlet or for the booster pump. This strainer must—

(1) For reciprocating engine-powered airships, have 8 to 16 meshes per inch; and

(2) For turbine engine-powered airships, prevent the passage of any object that could restrict fuel flow or damage any fuel-system component.

(b) The clear area of each fuel tank outlet strainer must be at least five times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

5.23 Pressure fueling system.

For pressure fueling systems, the following apply:

(a) Each pressure fueling system fuel manifold connection must have means to prevent the escape of hazardous quantities of fuel from the system if the fuel entry valve fails.

(b) An automatic shutoff means must be provided to prevent the quantity of fuel in each tank from exceeding the maximum quantity approved for that tank. This means must allow checking for proper shutoff operation before each fueling of the tank.

(c) A means must be provided to prevent damage to the fuel system in the event of failure of the automatic shutoff means prescribed in paragraph (b) of this section.

(d) All parts of the fuel system up to the tank which are subjected to fueling pressures must have a proof pressure of 1.33 times, and an ultimate pressure of at least 2.0 times the surge pressure likely to occur during fueling.

Fuel System Components

5.24 Fuel pumps.

(a) Main pumps. Each fuel pump required for proper engine operation, or required to meet the fuel system requirements of this subpart (other than those in paragraph (b) of this section), is a main pump. For each main pump, provision must be made to allow the by pass of each positive displacement fuel pump other than a fuel injection pump (a pump that supplies the proper flow and pressure for fuel injection when the injection is not accomplished in a carburetor) approved as part of the engine.

(1) For recprocating engine installations having fuel pumps to supply fuel to the engine, these must be at least one main pump which must be either directly driven by the engine or be electrically driven. If the pump is electrically driven, the following apply:

(i) The electrical system, including the power supply, for the main pump for each engine must be independent of the electrical system for each main pump for any other engine.

(ii) The electrical system, including the power supply, for the emergency pump for each engine must be independent of the electrical system for the main pump for the same engine.

(iii) Except during the engine starting operation, the independent fuel pump electrical systems must not be connected to any common electrical load, either engine or airframe, during normal operations.

(iv) A failure in any other electrical system, including both engine and airframe systems, must not adversely affect any part of any fuel pump electrical system.

(v) The main fuel pump control switches in the cockpit must be independent from all other switches and guarded to prevent inadvertent actuation.

(2) For turbine engine installations, each fuel pump required for proper engine operation, or required to meet the fuel system requirements of this subpart (other than those in paragraph (b) of this section), is a main pump. In addition—

(i) There must be a least one main pump for each turbine engine;

(ii) The power supply for the main pump for each engine must be independent of the power supply for each main pump for any other engine; and

(iii) For each main pump, provision must be made to allow the by pass of each positive displacement fuel pump other than a fuel injection pump approved as part of the engine.

(b) Emergency pumps. There must be an emergency pump immediately available to supply fuel to the engine if any main pump (other than a fuel injection pump approved as part of an engine) fails. The power supply for each emergency pump must be independent of the power supply for each corresponding main pump.

(c) Warning means. If both the normal pump and emergency pump operate continuously, there must be a means to indicate to the appropriate flight crewmember a malfunction of either pump.

(d) Operation of any fuel pump may not affect engine operation so as to create a hazard, regardless of the engine power or thrust setting or functional status of any other fuel pump.

5.25 Fuel system lines and fittings.

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure and accelerated flight conditions.

(b) Each fuel line connected to components of the airship between which relative motion could exist must have provisions for flexibility.

(c) Each flexible connection in fuel lines that may be under pressure and subjected to axial loading must use flexible hose assemblies.

(d) Each flexible hose must be approved or must be shown to be suitable for the particular application.

(e) No flexible hose that might be adversely affected by exposure to high temperatures may be used where excessive temperatures will exist during operation or after engine shutdown.

5.26 Fuel system components.

Fuel system components in an engine nacelle or in the car must be protected from damage which could result in spillage of enough fuel to constitute a fire hazard as a result of a wheels-up landing on a paved runway.

5.27 Fuel valves and controls.

(a) There must be a means to allow appropriate flight crewmembers to rapidly shut off the fuel to each engine individually in flight.

(b) No shutoff valve may be on the engine side of any firewall. In addition, there must be means to—

(1) Guard against inadvertent operation of each shutoff valve; and

(2) Allow appropriate flight crewmembers to reopen each valve rapidly after it has been closed.

(c) Each valve and fuel system control must be supported so that loads resulting from its operation or from accelerated flight conditions are not transmitted to the lines connected to the valve.

(d) Each valve and fuel system control must be installed so that gravity and vibration will not affect the selected position.

(e) Each fuel valve handle and its connections to the valve mechanism must have design features that minimize the possibility of incorrect installation.

(f) Each check valve must be constructed, or otherwise incorporate provisions, to preclude incorrect installation of the valve.

(g) Fuel tank selector valves must--

(1) Require a separate and distinct action to place the selector in the "OFF" position; and

(2) Have the tank selector positions located in such a manner that it is impossible for the selector to pass through the "OFF" position when changing from one tank to another.

5.28 Fuel strainer or filter.

There must be a fuel strainer or filter between the fuel tank outlet and the inlet of either the fuel metering device or an engine-driven positive displacement pump, whichever is nearer the fuel tank outlet. This fuel strainer or filter must--

(a) Be accessible for draining and cleaning and must incorporate as screen or element which is easily removable;

(b) Have a sediment trap and drain except that it need not have a drain if the strainer or filter is easily removable for drain purposes;

(c) Be mounted so that its weight is not supported by the connecting lines or by the inlet or outlet connections of the strainer or filter itself; and

(d) Have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in Part 33 of the FAR, or equivalent standards.

5.29 Fuel system drains.

(a) There must be at least one drain to allow safe drainage of the entire fuel system with the airship in its normal ground attitude.

(b) Each drain required by paragraph (a) of this section and § 5.19 must—

(1) Discharge clear of all parts of the airship;

(2) Have manual or automatic means for positive locking in the closed position; and

(3) Have a drain valve that is readily accessible and which can be easily opened and closed; and that is either located or protected to prevent fuel spillage in the event of a landing with landing gear retracted.

5.30 Fuel jettisoning system.

If a fuel jettisoning system is installed, it must be able to jettison fuel at the rate of 100 gallons per minute. The system must be designed so that is is not possible to jettison that fuel necessary to make a safe landing.

(a) Fuel jettisoning must be demonstrated in a descent, climb, and level flight. During this flight test, it must be shown that—

(1) The fuel jettisoning system and its operation are free from fire hazard;

(2) The fuel discharges clear of any part of the airship;

(3) Fuel or fumes do not enter any part of the airship; and

(4) The jettisoning operation does not adversely affect the controllability of the airship.

(b) The fuel jettisoning valve must be designed to allow the crew to close the valve during any part of the jettisoning operation.

(c) Unless it is shown that engine operation, engine vectoring or operation of auxiliary power units does not adversely affect fuel jettisoning, there must be a placard, adjacent to the jettisoning control, to warn crew members against jettisoning during those operations.

(d) The fuel jettisoning system must be designed so that any reasonably probable single malfunction in the system will not result in a hazardous condition due to the inability to jettison fuel.

Oil System

5.31 General.

(a) Each engine must have an independent oil system that can supply it with an appropriate quantity of oil at a temperature not above that safe for continuous operation.

(b) The usable oil tank capacity may not be less than the product of the endurance of the airship under critical operating conditions and the maximum oil consumption of the engine under the same conditions, plus a suitable margin to ensure adequate circulation and cooling.

(c) For an oil system without an oil transfer system, only the usable oil tank capacity may be considered. The amount of oil in the engine oil lines, the oil radiator, and the feathering reserve, may not be considered.

(d) If an oil transfer system is used, the amount of oil in the transfer lines that can be pumped by the transfer pump may be included in the oil capacity.

5.32 Oil tanks.

(a) Installation. Each oil tank must be installed to—

(1) Meet the requirements § 5.17 (a) and (b); and

(2) Withstand any vibration, inertia, and fluid loads expected in operation.

(b) Expansion space. Oil tank expansion space must be provided so that--

(1) Each oil tank used with a reciprocating engine has an expansion space of not less than the greater of 10 percent of the tank capacity or 0.5 gallons, and each oil tank used with a turbine engine has an expansion space of not less than 10 percent of the tank capacity; and

(2) It is impossible to fill the expansion space inadvertently with the airship in the normal ground attitude.

(c) Filler connection. Each recessed oil tank filler connection that can retain any appreciable quantity of oil must have a drain that discharges clear of each part of the airship. In addition—

(1) Each oil tank filler cap must provide an oil tight seal; and

(2) Each oil tank filler must be marked as prescribed in § 7.21(c).

(d) Vent. Oil tanks must be vented as follows:

(1) Each oil tank must be vented to the engine crankcase from the top part of the expansion space so that the vent connection is not covered by oil under any normal flight conditions.

(2) Oil tank vents must be arranged so that condensed water vapor that might freeze and obstruct the line cannot accumulate at any point.

(e) Outlet. No oil tank outlet may be enclosed by any screen or guard that would reduce the flow of oil below a safe value at any operating temperature. No oil tank outlet diameter may be less than the diameter of the engine oil pump inlet. Each oil tank used with a turbine engine must have means to prevent entrance into the tank itself, or into the tank outlet, of any object that might obstruct the flow of oil through the system. There must be a shutoff valve at the outlet of each oil tank used with a turbine engine, unless the external portion of the oil system (including oil tank supports) is fireproof.

(f) Flexible liners. Each flexible oil tank liner must be of an acceptable kind.

5.33 Oil tank tests.

Each oil tank must be tested under § 5.16 except that--

(a) The applied pressure must be 5 p.s.i. for the tank construction instead of the pressures specified in § 5.16(a);

(b) For a tank with a nonmetallic liner, the test fluid must be oil rather than fuel as specified in § 5.16(d), and the slosh test on a specimen liner must be conducted with the oil at 250°F; and

(c) For pressurized tanks used with a turbine engine, the test pressure may not be less than 5 p.s.i. plus the maximum operating pressure of the tank.

5.34 Oil lines and fittings.

(a) Oil lines. Oil lines must meet § 5.25, and must accommodate a flow of oil at a rate and pressure adequate for proper engine functioning under any normal operating condition.

(b) Breather lines. Breather lines must be arranged so that—

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

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

(3) The breather does not discharge into the engine air-induction system; and

(4) The breather outlet is protected against blockage by ice or foreign matter.

5.35 Oil strainer or filter.

(a) Each turbine engine installation must incorporate an oil strainer or filter through which all of the engine oil flows and which meets the following requirements:

(1) Each oil strainer or filter that has a bypass, must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter completely blocked.

(2) The oil strainer or filter must have the capacity (with respect to operating limitations established for the engine) and the mesh to ensure that engine oil system functioning is not impaired when the oil is contaminated to a degree (with respect to particle size and density) that is greater than that established for the engine in Part 33 of the FAR or equivalent standards.

(3) The oil strainer or filter, unless it is installed at an oil tank outlet, must incorporate an indicator that will indicate contamination of the screen before it reaches the capacity established in accordance with subparagraph (2) of this paragraph.

(4) The bypass of a strainer or filter must be constructed and installed so that the release of collected contaminants is minimized by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flow path.

(5) An oil strainer or filter that has no bypass, except one that is installed at an oil tank outlet, must have a means to connect it to the warning system required in § 6.3(c)(7).

(b) Each oil strainer or filter in a powerplant installation using reciprocating engines must be constructed and installed so that oil will flow at the normal rate through the rest of the system with the strainer or filter element completely blocked.

5.36 Oil system drains.

There must be at least one accessible drain that--

(a) Allows safe drainage of the entire oil system; and

(b) Has manual or automatic means for positive locking in the closed position.

5.37 Oil radiators.

If installed, each oil radiator and its supporting structure must be able to withstand the vibration, inertia, and oil pressure loads to which it would be subjected in operation.

5.38 Propeller feathering system.

(a) If the propeller feathering system depends on engine oil, there must be means to trap an amount of oil in the tank if the supply becomes depleted due to failure of any part of the lubricating system, other than the tank itself.

(b) The amount of trapped oil must be enough to accomplish feathering and must be available only to the feathering pump.

(c) The ability of the system to accomplish feathering with the trapped oil must be shown.

(d) Provisions must be made to prevent sludge or other foreign matter from affecting the safe operation of the propeller feathering system.

Cooling

5.39 General.

The powerplant cooling provisions must be able to maintain the temperatures of powerplant components and engine fluids, within the temperature limits established during ground and flight operations to the maximum altitude for which approval is requested.

5.40 Cooling tests.

(a) General. Compliance with § 5.39 must be shown under critical ground and flight operating conditions (including loiter, hover, climb, and descent) to the maximum altitude for which approval is requested. For turbosupercharged engines, each turbosupercharger must be operated through that part of the climb profile for which operation with the turbosupercharger is requested and in a manner consistent with its intended operation. For these tests, the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in paragraph (b), of this

section, the recorded powerplant temperature must be corrected under paragraphs (c) and (d) of this section, unless a more rational correction method is applicable.

(2) No corrected temperature determined under subparagraph (1) of this paragraph may exceed established limits.

(3) The fuel used during the cooling tests must be the most critical grade approved for the engines, and the mixture settings must be those used in normal operation.

(b) Maximum ambient atmospheric temperature. A maximum ambient atmospheric temperature corresponding to sea level conditions of at least 100°F must be established. The assumed temperature lapse rate is 3.6°F per thousand feet of altitude above sea level. However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 100°F.

(c) Correction factor (except cylinder barrels). Unless a more rational correction applies, temperatures of engine fluids and powerplant components (except cylinder barrels) for which temperature limits are established, must be corrected by adding to them the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum component or fluid temperature recorded during the cooling test.

(d) Correction factor for cylinder barrel temperatures. Cylinder barrel temperatures must be corrected by adding to them 0.7 times the difference between the maximum ambient atmospheric temperature and the temperature of the ambient air at the time of the first occurrence of the maximum cylinder barrel temperature recorded during the cooling test.

5.41 Cooling test procedures.

(a) General. For each stage of flight, the cooling test must be conducted with the airship—

(1) In the configuration most critical for cooling (including cowl flap settings selected by the applicant for reciprocating engine powered airships, and where vectored thrust is provided, including vectoring procedures established by the applicant); and

(2) Under the conditions most critical for cooling.

(b) Temperature stabilization. For the purpose of the cooling tests, a temperature is "stabilized" when its rate of change is less than 2 degrees F. per minute. The following stabilization rules apply. For each airships, and for each stage of flight—

(1) The temperatures must be stabilized under the conditions from which entry is made into the stage of flight being investigated; or

(2) If the entry condition normally does not allow temperatures to stabilize, operation through the full entry condition must be conducted before entry into the stage of flight being investigated in order to allow the temperatures to attained their natural levels at the time of entry.

(c) Duration of test. For each stage of flight the tests must be continued until—

(1) The component and engine-fluid temperatures stabilize;

(2) The stage of flight is completed; or

(3) An operating limitation is reached.

(d) Turbine engine powered airships. The following additional requirement applies: The takeoff cooling test must be preceded by a period during which the powerplant component and engine-fluid temperatures are stabilized with the engines at ground idle.

(e) Reciprocating engine-powered airships. The following additional requirements apply:

(1) For each single-engine airship, engine-cooling tests during climb must be conducted as follows:

(i) Engine temperature must be stabilized in level flight with the engine at not less than 75 percent of maximum continuous power.

(ii) The climb must begin at the lowest practicable altitude with the engine at takeoff power for the specified duration of takeoff power and thence with maximum continuous power.

(iii) The climb must be conducted at a speed not more than the best rate of climb speed with maximum continuous power unless the slope of the flight path at the speed chosen for the cooling test is equal to or greater than the minimum required angle of climb determined under § 2.8 and the airship has a cylinder head temperature indicator.

(iv) The climb must be continued at maximum continuous power for at least 5 minutes after the occurrence of the highest temperature recorded.

(2) For each multiengine airship engine-cooling tests during climb must be conducted as follows:

(i) One engine is inoperative.

(ii) Engine temperatures must be stabilized in level flight with the operating engines at not less than 75 percent of maximum continuous power.

(iii) The climb must begin at the lowest practicable altitude with the engine at takeoff power for the specified duration of takeoff power and thence with maximum continuous power.

(iv) The climb must be conducted at a speed not more than the best rate of climb speed with maximum continuous power unless the slope of the flight path at the speed chosen for the cooling test is equal to or greater than the minimum required angle of climb determined under § 2.9 and the airship has a cylinder head temperature indicator.

(v) The climb must be continued at maximum continuous power for at least 5 minutes after the occurrence of the highest temperature recorded.

Liquid Cooling

5.42 Installation.

(a) General. Each liquid-cooled engine must have an independent cooling system (including coolant tank) installed so that--

(1) Each coolant tank is supported so that tank loads are distributed over a large part of the tank surface;

(2) There are pads between the tank and its supports to prevent chafing; and

(3) No air or vapor can be trapped in any part of the system, except the expansion tank, during filling or during operation.

Padding must be nonabsorbent or must be treated to prevent the absorption of flammable fluids.

(b) Coolant tank. The tank capacity must be at least one gallon, plus 10 percent of the cooling system capacity. In addition—

(1) Each coolant tank must be able to withstand the vibration, inertia, and fluid loads to which it may be subjected in operation;

(2) Each coolant tank must have an expansion space of at least 10 percent of the total cooling system capacity; and

(3) It must be impossible to fill the expansion space inadvertently with the airship in the normal ground attitude.

(c) Filler connection. Each coolant tank filler connection must be marked as specified in § 7.21(c). In addition—

(1) Spilled coolant must be prevented from entering the coolant tank compartment or any part of the airship other than the tank itself; and

(2) Each recessed coolant filler connection must have a drain that discharges clear of the entire airship.

(d) Lines and fittings. Each coolant system line and fitting must meet the requirements of § 5.25, except that the inside diameter of the engine coolant inlet and outlet lines may not be less than the diameter of the corresponding engine inlet and outlet connections.

(e) Radiators. Each coolant radiator must be able to withstand any vibration, inertia, and coolant pressure load to which it may normally be subjected. In addition—

(1) Each radiator must be supported to allow expansion due to operating temperatures and prevent the transmittal of harmful vibration to the radiator; and

(2) If flammable coolant is used, the air intake duct to the coolant radiator must be located so that (in case of fire) flames from the nacelle cannot strike the radiator.

(f) Drains. There must be an accessible drain that—

(1) Drains the entire cooling system (including the coolant tank, radiator, and the engine) when the airship is in the normal ground attitude;

(2) Discharges clear of the entire airship; and

(3) Has means to positively lock it closed.

5.43 Coolant tank tests.

Each coolant tank must be tested under § 5.16, except that—

(a) The test required by § 5.16(a)(1) must be replaced with a similar test using the sum of the pressure developed during the maximum ultimate acceleration with a full tank or a pressure of 3.5 pounds per square inch, whichever is greater, plus the maximum working pressure of the system; and

(b) For a tank with a nonmetallic liner the test fluid must be coolant rather than fuel as specified in § 5.16(d), and the slosh test on a specimen liner must be conducted with the coolant at operating temperature.

Induction System

5.44 Air induction.

(a) The air induction system for each engine must supply the air required by that engine under the operating conditions for which certification is requested.

(b) Each reciprocating engine installation must have at least two separate air intake sources and must meet the following:

(1) Primary air intakes may open within the cowling if that part of the cowling is isolated from the engine accessory section by a fire-resistant diaphragm or if there are means to prevent the emergence of backfire flames.

(2) Each alternate air intake must be located in a sheltered position and may not open within the cowling if the emergence of backfire flames will result in a hazard.

(3) The supplying of air to the engine through the alternate air intake system may not result in a loss of excessive power in addition to the power loss due to the rise in air temperature.

(c) For turbine engine-powered installations—

(1) There must be means to prevent hazardous quantities of fuel leakage or overflow from drains, vents, or other components of flammable fluid systems from entering the engine intake system; and

(2) The air inlet ducts must be located or protected so as to minimize the ingestion of foreign matter during takeoff, landing, and taxiing.

5.45 Induction system icing protection.

(a) Reciprocating engines. Each reciprocating engine air-induction system must have means to prevent and eliminate icing. Unless this is done by other means, it must be shown that, in air free of visible moisture at a temperature of 30° F—

(1) Each airship with sea level engines using conventional venturi carburetors has a preheater that can provide a heat rise of 90° F with the engines at 75 percent of maximum continuous power;

(2) Each airship with altitude engines using conventional venturi carburetors has a preheater that can provide a heat rise of 120° with the engines at 75 percent of maximum continuous power;

(3) Each airship with altitude engines using carburetors tending to prevent icing has a preheater that, with the engines at 60 percent of maximum continuous power, can provide a heat rise of 100° F;

(4) Each single-engine airship with a sea-level engine using a carburetor tending to prevent icing has a sheltered alternate source of air with a preheat of not less than that provided by the engine cooling air downstream of the cylinders; and

(5) Each multiengine airship with sea-level engines using a carburetor tending to prevent icing has a preheater that can provide a heat rise

of 90° F with the engines at 75 percent of maximum continuous power.

(b) Turbine engines.

(1) Each turbine engine and its air-inlet system must operate throughout the flight-power range of the engine (including idling), within the limitations established for the airship, without the accumulation of ice on engine or inlet system components that would adversely affect engine operation or cause a serious loss of power or thrust—

(i) Under the icing conditions specified in Appendix C of Part 25 of the FAR; and

(ii) In snow, both falling and blowing.

(2) Each turbine engine must idle for 30 minutes on the ground, with the air bleed available for engine icing protection at its critical condition, without adverse effect, in an atmosphere that is at a temperature between 15° and 30° F (between -9° and -1° C) and has a liquid water content not less than 0.3 grams per cubic meter in the form of drops having a mean effective diameter not less than 20 microns, followed by momentary operation at takeoff power or thrust. During the 30 minutes of idle operation, the engine may be run up periodically to a moderate power or thrust setting in a manner acceptable to the Administrator.

(c) For airships with reciprocating engines having superchargers to pressurize the air before it enters the carburetor, the heat rise in the air caused by that supercharging at any altitude may be utilized in determining compliance with paragraph (a) of this section if the heat rise utilized is that which will be available, automatically, for the applicable altitudes and operating condition because of supercharging.

5.46 Carburetor air preheater design.

If a carburetor air preheater is installed, it must be designed and constructed to—

(a) Ensure ventilation of the preheater when the engine is operated in cold air;

(b) Allow inspection of the exhaust manifold parts that it surrounds; and

(c) Allow inspection of critical parts of the preheater itself.

5.47 Induction system ducts.

(a) Each induction system duct must have a drain to prevent the accumulation of fuel or moisture in the normal ground and flight attitudes. No drain may discharge where it will cause a fire hazard.

(b) Each duct connected to components between which relative motion could exist must have means for flexibility.

5.48 Induction system screens.

If induction system screens are used—

(a) Each screen must be upstream of the carburetor.

(b) No screen may be in any part of the induction system that is the only passage through which air can reach the engine, unless—

(1) The available preheat is at least 100° F; and

(2) The screen can be deiced by heated air;

(c) No screen may be deiced by alcohol alone; and

(d) It must be impossible for fuel to strike any screen.

5.49 Turbine engine bleed-air system.

For turbine engine bleed-air systems, the following apply:

(a) No hazard may result if duct rupture or failure occurs anywhere between the engine port and the airship unit served by the bleed air.

(b) The effect on airship and engine performance of using maximum bleed air must be established.

(c) Hazardous contamination of cabin air systems may not result from failures of the engine lubricating system.

Exhaust System

5.50 General.

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in any personnel compartment.

(b) 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.

(c) Each exhaust system component must be separated by fireproof shields from adjacent flammable parts of the airship that are outside the engine compartment.

(d) No exhaust gases may discharge near any flammable fluid, vent, or drain that may cause a fire hazard.

(e) Each exhaust system component must be ventilated to prevent points of excessively high temperature.

(f) No exhaust gases may be discharged where they will cause a glare seriously affecting pilot vision at night.

(g) If significant traps exist, each turbine engine exhaust system must have drains discharging clear of the airship, in any normal ground and flight attitude, to prevent fuel accumulation after the failure of an attempted engine start.

(h) Each exhaust heat exchanger must incorporate means to prevent blockage of the exhaust port after any internal heat exchanger failure.

5.51 Exhaust manifold.

(a) Each exhaust manifold must be fireproof and corrosion-resistant, and must have means to prevent failure due to expansion caused by operating temperatures.

(b) Each exhaust manifold must be supported to withstand the vibration and inertia loads to which it may be subjected in operation.

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

5.52 Exhaust heat exchangers.

For reciprocating engine-powered airships, the following apply—-

(a) Each exhaust heat exchanger must be constructed and installed to withstand the vibration, inertia, and other loads that it may be subjected to in normal operation. In addition—

(1) Each exchanger must be suitable for continued operation at high temperatures and resistant to corrosion from exhaust gases;

(2) There must be means for inspection of critical parts of each exchanger; and

(3) Each exchanger must be ventilated wherever it is subject to contact with exhaust gases.

(b) Each heat exchanger used for heating ventilating air must be constructed so that exhaust gases may not enter the ventilating air.

Powerplant Controls and Accessories

5.53 Powerplant controls: general.

(a) Powerplant controls must be located and arranged under § 4.31 and marked under § 7.20(a).

(b) Each flexible control must be an acceptable kind.

(c) Each control must be able to maintain any necessary position without--

(1) Constant attention by flight crewmembers; or

(2) Tendency to creep due to control loads or vibration.

(d) Each control must be able to withstand operating loads without failure or excessive deflection.

(e) For turbine engine-powered airships, no single failure or malfunction, or probable combination thereof, in any powerplant control system may cause the failure of any powerplant function necessary for safety.

(f) The portion of each powerplant control located in the engine compartment that is required to be operated in the event of fire must be at least fire resistant.

(g) Powerplant valve controls located in the cockpit must have--

(1) For manual valves, positive stops, or in the case of fuel valves, suitable index provisions, in the open and closed position; and

(2) For power-assisted valves, a means to indicate to the flightcrew when the valve--

(i) Is in the fully open or fully closed position; or

(ii) Is moving between the fully open and fully closed position.

5.54 Engine controls.

* (a) There must be a separate and independent power or thrust control for each engine, and a separate control for each supercharger that requires a control. *

* (b) Each power, thrust, and supercharger control must give a positive and immediately responsive means for controlling its engine or supercharger.

(c) Power controls must be arranged to allow separate control and simultaneous control of all engines.

(d) If a power or thrust control incorporates a fuel-shutoff feature, the control must have a means to prevent the inadvertent movement of the control into the shutoff position. The control must-- *

(1) Have a positive lock or stop at the idle position; and

(2) Require a separate and distinct operation to place the control in the shutoff position.

5.55 Ignition switches.

(a) Ignition switches must control each ignition circuit on each engine.

(b) There must be means to quickly shut off all ignition on multiengine airships by the groupings of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines for which continuous ignition is not required, and each master ignition control must have a means to prevent its inadvertent operation.

5.56 Mixture controls. If there are mixture controls, each engine must have a separate control, and each mixture control must have guards or must be shaped or arranged to prevent confusion by feel with other controls. The controls must be grouped and arranged to allow separate control of each engine and simultaneous control of all engines.

5.57 Propeller speed and pitch controls.

(a) If there are propeller speed or pitch controls, they must be grouped and arranged to allow--

(1) Separate control of each propeller; and

(2) Simultaneous control of all propellers.

(b) The controls must allow ready synchronization of all propellers on multiengine airships.

5.58 Propeller feathering controls.

If there are propeller feathering controls, each propeller must have a separate control. Each control must have means to prevent inadvertent operation.

5.59 Carburetor air temperature controls.

There must be a separate carburetor air temperature control for each engine.

5.60 Powerplant accessories.

(a) Each engine-driven accessory must--

(1) Be approved for mounting on the engine involved;

(2) Use the provisions on the engine for mounting; and

(3) Be sealed to prevent contamination of the engine oil system and the accessory system.

(b) Electrical equipment subject to arcing or sparking must be installed to minimize the probability of contact with any flammable fluids or vapors that might be present in a free state.

(c) Each generator rated at or more than 6 kilowatts must be designed and installed to minimize the probability of a fire hazard in the event it malfunctions.

(d) The generator cooling provisions must be able to maintain the temperatures of generator components within the established temperature limits during ground and flight operations.

5.61 Engine ignition systems.

(a) Each battery ignition system must be supplemented by a generator that is automatically available as an alternate source of electrical energy to allow continued engine operation if any battery becomes depleted.

(b) The capacity of batteries and generators must be large enough to meet the simultaneous demands of the engine-ignition system and the greatest demands of any electrical system components that draw from the same source.

(c) The design of the engine-ignition system must account for--

(1) The condition of an inoperative generator;

(2) The condition of a completely depleted battery with the generator running at its normal operating speed; and

(3) The condition of a completely depleted battery with the generator operating at idling speed if there is only one battery.

(d) There must be means to warn appropriate crewmembers if malfunctioning of any part of the electrical system is causing the continuous discharge of any battery used for engine ignition.

(e) Each turbine engine ignition system must be independent of any other turbine engine ignition system and must be protected from airframe electrical loads and/or faults.

5.62 Vectored thrust controls.

* If thrust vectoring is provided, the following requirements must be met:

(a) Each vectoring control must be independent of all other controls, and must provide a positive and immediate response.

(b) The vector controls must be readily available to the pilot, and must be such that the pilot can readily and positively select each appropriate thrust position.

(c) If separate vector controls are provided for each propulsor--

(1) They must be arranged to allow separate control and simultaneous control of all propulsors; and

(2) The airship must be demonstrated to have safe flight characteristics when the vectored thrust units are in the normal flight position on one side and in the fully vectored position on the other, with engines operating at maximum takeoff power.

(d) In the event of a vectoring-system failure, an auxiliary means must be provided to return the system to the normal-operating position. *

5.63 Auxiliary power unit controls.

Means must be provided at the pilots station for starting, stopping, and emergency shutdown of each installed auxiliary power unit.

Powerplant Fire Protection

5.64 Nacelle areas adjacent to engine firewalls.

Components, lines, and fittings located adjacent to the engine-compartment firewall must be constructed of such materials and located at such distances from the firewall that they will not suffer damage sufficient to endanger the airship if a portion of the engine side of the firewall is subjected to a flame temperature of not less than 2,000 degrees for 15 minutes.

5.65 Lines, fittings, and components.

(a) Except as provided in paragraph (b) of this section, each component, line, and fitting carrying flammable fluids, gas, or air in any area subject to engine fire conditions must be at least fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluids. Flexible hose assemblies (hose and end fittings) must be approved. An integral oil sump of less than 25 quart capacity on a

reciprocating engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Paragraph (a) of this section, does not apply to—

(1) Lines, fittings, and components which are already approved as part of a type certificated engine; and

(2) Vent and drain lines, and their fittings, whose failure will not result in, or add to, a fire hazard.

5.66 Ventilation.

Each compartment containing any part of the powerplant installation must have provision for ventilation to prevent the accumulation of flammable vapors.

5.67 Shutoff means.

(a) Each engine installation must have means to shut off or otherwise prevent hazardous quantities of fuel, oil, and other flammable liquids from flowing into, within, or through any engine compartment, except in lines, fittings, and components forming an integral part of an engine.

(b) The closing of the fuel shutoff valve for any engine may not make fuel unavailable to the remaining engines.

(c) Operation of any shutoff means may not interfere with the later emergency operation of other equipment such as propeller feathering devices.

(d) Each shutoff must be outside of the engine compartment unless an equal degree of safety is provided with the shutoff inside the compartment.

(e) No hazardous amount of flammable fluid may drain into the engine compartment after shutoff.

(f) There must be means to guard against inadvertent operations of each shutoff means, and to make it possible for the crew to reopen the shutoff means in flight after it has been closed.

(g) Turbine engine installations need not have an engine oil system shutoff if—

(1) The oil tank is integral with, or mounted on, the engine; and

(2) All oil system components external to the engine are fireproof or located in areas not subject to engine fire conditions.

5.68 Firewalls.

(a) Each engine, auxiliary-power unit, fuel-burning heater, and other combustion equipment intended for operation in flight, must be isolated from the rest of the airship by firewalls, shrouds, or other equivalent means.

(b) Each firewall or shroud must be constructed so that no hazardous quantity of liquid, gas, or flame can pass from the engine compartment to other parts of the airship.

(c) Each opening in the firewall or shroud must be sealed with close-fitting, fireproof grommets, bushings, or firewall fittings.

(d) Each firewall and shroud must be fireproof and protected against corrosion.

(e) Compliance with the criteria for fireproof materials or components, must be shown as follows:

(1) The flame to which the materials or components are subjected must be 2,000±50° F.

(2) Sheet materials approximately 10 inches square must be subjected to the flame from a suitable burner.

(3) The flame must be large enough to maintain the required test temperature over an area approximately 5 inches square.

(f) Firewall materials and fittings must resist flame penetration for at least 15 minutes.

(g) The following materials may be used in firewalls or shrouds without being tested as required by this section:

(1) Stainless steel sheet, 0.015 inch thick.

(2) Mild steel sheet (coated with aluminum or otherwise protected against corrosion), 0.018 inch thick.

(3) Terne plate, 0.018 inch thick.

(4) Monel metal, 0.018 inch thick.

(5) Steel or copper base alloy firewall fittings.

5.69 Engine accessory compartment diaphragm.

For aircooled radial engines, the engine power section and all portions of the exhaust system must be isolated from the engine accessory compartment by a diaphragm that meets the firewall requirements of § 5.68.

5.70 Engine cowling.

(a) The cowling must be constructed and supported so that it can resist the vibration, inertia, and air loads to which it may be subjected in operation.

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

(c) Cowling must be at least fire-resistant.

(d) All surfaces aft of or near an opening in the engine compartment cowling must be at least fire-resistant for a distance of at least 24 inches of the opening.

(e) Each part of the cowling subjected to high temperatures due to its nearness to exhaust-system ports or exhaust gas impingement must be fireproof.

5.71 [Reserved].

5.72 Fire-detector systems.

For multiengine turbine engine-powered airships and multiengine reciprocating engine powered airships incorporating tubosuperchargers, the following apply:

(a) There must be a means which ensures the prompt detection of a fire in an engine compartment.

(b) Each fire detector must be constructed and installed to withstand the vibration, inertia, and other loads to which it may be subjected in operation.

(c) No fire detector may be affected by an fluids or fumes that might be present.

(d) There must be a means to allow the crew to check, in flight, the functioning of each fire detector electric circuit.

(e) Wiring and other components of each fire-detector system in an engine compartment must be at least fire resistant.

5.73 Vectored thrust.

For airships utilizing vectored-thrust systems, the engine exhaust impingement effect on the airship may not cause an increase in the temperature of airship materials or components beyond safe limits.

SUBPART VI - EQUIPMENT

General

6.1 Function and installation.

Each item of installed equipment must—

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

(b) Be labeled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(c) Be installed according to limitations specified for that equipment; and

(d) Function properly when installed.

6.2 Flight and navigation instruments.

The following flight and navigational instruments are required:

(a) An airspeed indicator.

(b) An altimeter (sensitive).

(c) A magnetic direction indicator.

(d) A free air-temperature indicator.

(e) Means to indicate pressure in the envelope and ballonets.

(f) Means for measuring the temperature differential between the lifting gas and the outside air.

(g) A means to indicate the pitch attitude of the airship.

(h) Rate-of-climb indicator.

6.3 Powerplant instruments.

The following are required powerplant instruments:

(a) For all airships:

(1) A fuel-quantity indicator for each fuel tank.

(2) An oil-quantity indicator for each oil tank (dipstick or sight gauge).

(3) An oil-pressure indicator for each independent pressure oil system of each engine.

(4) An oil-temperature indicator for each engine and for each turbosupercharger oil system that is separate from other oil systems.

(5) A fire-warning indicator for those airships required to comply with § 5.72.

(b) For reciprocating engine-powered airships. In addition to the powerplant instruments required by paragraph (a) of this section, the following powerplant instruments are required:

(1) A tachometer for each engine.

(2) A cylinder head temperature indicator for each engine.

(3) A fuel-pressure indicator (to indicate the pressure at which the fuel is supplied) for each pump-fed engine.

(4) A manifold-pressure indicator for each altitude engine.

(5) For turbosupercharger installations, if limitations are established for either carburetor air inlet temperature or exhaust gas temperature, indicators must be furnished for each temperature for which the limitation is established unless it is shown that the limitation will not be exceeded in all intended operations.

(c) For turbine engine-powered airships. In addition to the powerplant instruments required by paragraph (a) of this section, the following powerplant instruments are required:

(1) A gas-temperature indicator for each engine.

(2) A fuel flowmeter for each engine.

(3) A tachometer (to indicate the speed of the rotors with established limiting speeds) for each engine.

(4) A means to indicate, to the flight crew, the operation of each engine starter that can be operated continuously but that is neither designed for continuous operation nor designed to prevent hazard if it failed.

(5) An indicator to indicate the functioning of the powerplant ice-protection system.

(6) An indicator for the fuel strainer or filter required by § 5.28 to indicate the occurrence of contamination of the strainer or filter before it reaches the capacity established in accordance with § 5.28(d).

(7) A warning means for the oil strainer or filter required by § 5.35, if it has no bypass, to warn the pilot of the occurrence of contamination of the strainer or filter screen before it reaches the capacity established in accordance with § 5.35(a)(2).

(8) A low oil-pressure warning means for each engine.

(9) An indicator to indicate the proper functioning of any heater used to prevent ice clogging of fuel-system components.

(d) For turbopropeller-powered airships. In addition to the powerplant instruments required by paragraphs (a) and (c) of this section, the following powerplant instruments are required:

(1) A torque indicator for each engine.

(2) Position-indicating means to indicate to the flight crew when the propeller-blade angle is below the flight low pitch position, for each propeller.

(3) A means to indicate to the pilot when the propeller is in reverse pitch, for each reversing propeller.

6.4 Miscellaneous equipment instruments.

The following are additional required instruments for auxiliary systems, if installed:

(a) Electrical-power generating systems

(1) Volt/load meter for each DC-generating system.

(2) Volt/frequency meter for each AC-generating system.

(b) Auxiliary-power unit

(1) Gas producer speed indicator for turbine engines.

(2) A temperature indicator to provide overtemp protection for turbine engines.

(3) An indicator to show that the APU is operating.

(4) An indicator to indicate APU shutdown when the APU switch is in the "ON" or "RUN" position.

(5) A tachometer for reciprocating engines.

(6) A cylinder head temperature indicator for air-cooled reciprocating engines.

(c) Thrust-vectoring system - A thrust vector angle position indicator for each engine or propeller.

(d) Hydraulic systems

(1) Hydraulic-quantity gauge for each system (dipstick or sight gauge).

(2) Hydraulic-pressure gauge for each system.

(e) Fly-by-wire/flight-control systems

(1) A means to indicate control surface position to the crew relative to commanded position.

* (2) A means to indicate to the pilot that the fly-by-wire/flight-control system is not functioning properly. *

6.5 Miscellaneous equipment.

The following miscellaneous equipment is required:

(a) A seat or berth for each occupant.

(b) A master switch arrangement.

(c) Electrical protective devices, as prescribed in this Criteria.

6.6 Equipment, systems, and installations.

(a) Each item of equipment, when performing its intended function, may not adversely affect--

(1) The response, operation, or accuracy of any equipment essential to safe operation; or

(2) The response, operation, or accuracy of any other equipment unless there is a means to inform the pilot of the effect.

(b) The equipment, systems, and installations of a multiengine airship must be designed to prevent hazards to the airship in the event of a probable malfunction or failure.

(c) The equipment, systems, and installations of a single-engine airship must be designed to minimize hazards to the airship in the event of a probable malfunction or failure.

6.7 Arrangement and visibility.

(a) Each flight, navigation, envelope and ballonet pressure, and powerplant instrument for use by any pilot must be plainly visible to him from his station with the minimum practicable deviation from his normal position and line of vision when he is looking forward along the flight path.

(b) For each multiengine airship, identical powerplant instruments must be located so as to prevent confusion as to which engine each instrument relates.

(c) Instrument panel vibration may not damage or impair the accuracy of any instrument.

* (d) For each airship, intended for operation under Instrument Flight Rules, the flight instruments required by § 6.2 and, as applicable, by Part 91 of the FAR, must be grouped on the instrument panel and centered as near as practicable about the vertical plane of the pilot's forward vision. In addition-- *

(1) The instrument that most effectively indicates the attitude must be on the panel in the top center position;

(2) The instrument that most effectively indicates airspeed must be adjacent to and directly to the left of the instrument in the top center position;

(3) The instrument that most effectively indicates altitude must be adjacent to and directly to the right of the instrument in the top center position;

(4) The instrument that most effectively indicates direction of flight, other than the magnetic direction indicator, must be adjacent to and directly below the instrument in the top center position.

(e) If a visual indicator is provided to indicate malfunction of an instrument, it must be effective under all probable cockpit-lighting conditions.

6.8 Warning, caution, and advisory lights.

If warning, caution, or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Administrator, be --

(a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

(b) Amber, for caution lights (lights indicating the possible need for future corrective action);

(c) Green, for safe operation lights; and

(d) Any other color, including white, for lights not described in paragraphs (a) through (c) of this section, provided the color differs sufficiently from the colors prescribed in paragraphs (a) through (c) of this section to avoid possible confusion.

6.9 Airspeed indicating system.

(a) Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied.

(b) Each airspeed system must be calibrated in flight to determine the system error. The system error, including position error, but excluding the airspeed indicator instrument calibration error, may not exceed five knots throughout the range from 20 knots to V_{MO}. *

(c) Each system must be arranged, so for as practicable, to prevent malfunction or serious error due to the entry of moisture, dirt, or other substances.

6.10 Static pressure system.

(a) Each instrument provided with static pressure case connections must be so vented that the influence of airship speed, the opening and closing of windows, airflow variations, moisture, or other foreign matter will least affect the accuracy of the instruments except as noted in paragraph (b)(3) of this section.

(b) If a static pressure system is necessary for the functioning of instruments, systems, or devices, it must comply with the provisions of subparagraphs (1) through (3) of this paragraph.

(1) The design and installation of a static pressure system must be such that--

(i) Positive drainage of moisture is provided;

(ii) Chafing of the tubing, and excessive distortion or restriction at bends in tubing, is avoided; and

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

(2) A proof test must be conducted to demonstrate the integrity of the static pressure system in the following manner: Evacuate the static pressure system to a pressure differential of approximately 1 inch of mercury or to a reading on the altimeter, 1,000 feet above the airship elevation at the time of the test. Without additional pumping for a period of 1 minute, the loss of indicated altitude must not exceed 100 feet on the altimeter.

* (3) For those airships intended for operation under Instrument Flight Rules or in known icing conditions, and if a static pressure system is provided for any instrument, device, or system required by the operating rules in Part 91, each static pressure port must be located in such a manner that the correlations between air pressure in the static pressure is not altered when the airship encounters icing conditions. An anti-icing means or an alternate source of static pressure may be used in showing compliance with this requirement. If the reading of the altimeter, when on the alternate static pressure system differs from the reading of the altimeter when on the primary static system by more than 50 feet, a correction card must be provided for the alternate static system. *

(c) Except as provided in paragraph (d) of this section, if the static pressure system incorporates both a primary and an alternate static pressure source, the means for selecting one or the other source must be designed so that--

(1) When either source is selected, the other is blocked off; and

(2) Both sources cannot be blocked off simultaneously.

(d) Paragraph (c)(1) of this section does not apply if it can be demonstrated that the static pressure system calibration, when either static pressure source is selected, is not changed by the other static pressure source being open or blocked.

(e) Each system must be designed and installed so that the error in indicated pressure altitude, at sea level, with a standard atmosphere, excluding instrument calibration error does not result in an error or more than ±30 feet in the speed range between 20 knots and V_{MO}.

6.11 Magnetic direction indicator.

(a) Except as provided in paragraph (b) of this section--

(1) Each magnetic direction indicator must be installed so that its accuracy is not excessively affected by the airship's vibration or magnetic fields; and

(2) The compensated installation may not have a deviation, in level flight, greater than 10 degrees on any heading.

(b) A magnetic nonstabilized direction indicator may deviate more than 10 degrees due to the operation of electrically-powered systems such as electrically-heated

windshields if either a magnetic stabilized direction indicator, which does not have a deviation in level flight greater than 10 degrees on any heading, or a gyroscopic direction indicator, is installed. Deviations of a magnetic nonstabilized-direction indicator of more than 10 degrees must be placarded in accordance with § 7.16(e).

6.12 Automatic pilot system.

If an automatic pilot system is installed, it must meet the following:

(a) Each system must be designed so that the automatic pilot can--

(1) Be quickly and positively disengaged by the pilots to prevent it from interfering with their control of the airship; or

(2) Be sufficiently overpowered by one pilot to let him control the airship.

(b) Unless there is automatic synchronization, each system must have a means to readily indicate to the pilot the alignment of the actuating device in relation to the control system it operates.

(c) Each manually operated control for the system operation must be readily accessible to the pilot. Each control must operate in the same plane and sense of motion as does the corresponding primary flight control. The direction of motion must be plainly indicated on or near each control.

(d) Each system must be designed and adjusted so that, within the range of adjustment available to the pilot, it cannot produce hazardous loads on the airship or create hazardous deviations in the flight path, under any flight condition appropriate to its use, either during normal operation or in the event of a malfunction, assuming that correction action begins within a reasonable period of time (recognition plus 3 seconds).

(e) Each system must be designed so that a single malfunction will not produce a hardover signal in more than one control axis. If the automatic pilot integrates signals from auxiliary controls or furnishes signals for operation of other equipment, positive interlocks and sequencing of engagement to prevent improper operation are required.

(f) There must be protection against adverse interaction of integrated components, resulting from a malfunction.

(g) If the automatic pilot system can be coupled to airborne navigation equipment, means must be provided to indicate to the flight crew the current mode of operation. Selector switch position is not acceptable as a means of indication.

6.13 Electronic flight instrument systems (EFIS).

Electronic display units used for attitude and navigation reference may be installed in lieu of mechanical or electromechanical instruments if--

(a) The display units--

(1) Are easily legible under all lighting conditions encountered in the cockpit, including direct sunlight;

(2) Do not inhibit the primary display of attitude;

(3) Incorporate sensory cues for the pilot that are equivalent to those in the instruments being replaced by the electronic display units; and

(4) Incorporate visual displays of instrument markings required by §§ 7.13 through 7.19, or visual displays that alert the pilot to abnormal operational values, or approaches to unsafe values, of any parameter required to be displayed by these criteria.

(b) The display units, including their systems and installations, must be designed so that one display of information essential to continued safe flight and landing will remain available to the crew, without need for immediate action for continued safe operation, after any single failure or probable combination of failures under any anticipated operating condition, or it must be shown that such failures are extremely improbable.

6.14 Instruments using a power supply.

For each instrument that uses a power supply, there must be a visual means to indicate when power adequate to sustain proper instrument performance is not being supplied. The power must be measured at or near the point where it enters the instruments. For electrical instruments, the power is considered adequate when the voltage is within approved limits.

6.15 Flight director systems.

If a flight director system is installed, means must be provided to indicate to the flight crew its current mode of operation. Selector switch position is not acceptable as a means of indication.

6.16 Powerplant instruments.

(a) Instruments and instrument lines.

(1) Each powerplant instrument line must meet the requirements of § 5.25.

(2) Each line carrying flammable fluids under pressure must--

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each powerplant instrument that utilizes flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) Fuel quantity indicator. There must be a means to indicate to the flight crewmembers the quantity of fuel in each tank during flight. An indicator, calibrated in either gallons or pounds, and clearly marked to indicate which scale is being used, may be used. In addition—

(1) Each fuel-quantity indicator must be calibrated to read "zero" during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under § 5.13;

(2) Each exposed sight gauge used as a fuel-quantity indicator must be protected against damage;

(3) Each sight gauge that forms a trap in which water can collect and freeze must have means to allow drainage on the ground;

(4) Tanks with interconnected outlets and airspaces may be considered as one tank and need not have separate indicators; and

(5) No fuel-quantity indicator is required for a small auxiliary tank that is used only to transfer fuel to other tanks if the relative size of the tank, the rate of fuel transfer, and operating instructions are adequate to—

(i) Guard against overflow; and

(ii) Give the flight crewmembers prompt warning if transfer is not proceeding as planned.

(c) Fuel flowmeter system. If a fuel flowmeter system is installed, each metering component must have a means to bypass the fuel supply if malfunctioning of that component severely restricts fuel flow.

(d) Oil-quantity indicator. There must be a means to indicate the quantity of oil in each tank—

(1) On the ground (such as by a stick gauge); and

(2) In flight, to the flight crewmembers, if there is an oil transfer system, or a reserve oil-supply system.

Electrical Systems and Equipment

6.17 General.

(a) Electrical system capacity. Each electrical system must be adequate for the intended use. In addition—

(1) Electrical power sources, their transmission cables, and their associated control and protective devices, must be able to furnish the required power at the proper voltage to each load circuit essential for safe operation; and

(2) Compliance with subparagraph (1) of this paragraph must be shown by an electrical load analysis, or by electrical measurements, that account for the electrical loads applied to the electrical system in probable combinations and for probable durations.

(b) Functions. For each electrical system, the following apply:

(1) Each system, when installed, must be—

(i) Free from hazards in itself, in its method of operation, and in its effects on other parts of the airship;

(ii) Protected from fuel, oil, water, other detrimental substances, and mechanical damage; and

(iii) So designed that the risk of electrical shock to crew, passengers, and ground personnel is reduced to a minimum.

(2) Electrical power sources must function properly when connected in combination or independently, except that alternators may depend on a battery for initial excitation or for stabilization.

(3) No failure or malfunction of any electrical-power source may impair the ability of any remaining source to supply load circuits essential for safe operation, except that the operation of an alternator that depends on a battery for initial excitation or for stabilization may be stopped by failure of that battery.

(4) Each electric power source control must allow the independent operation of each source, except that controls associated with alternators that depend on a battery for initial excitation or for stabilization need not break the connection between the alternator and its battery.

(c) Generating system. There must be at least one generator if the electrical system supplies power to load circuits essential for safe operation. In addition—

(1) Each generator must be able to deliver its continuous rated power;

(2) Generator voltage control equipment must be able to regulate the generator output within rated limits;

(3) Each generator must have a reverse current cutout designed to disconnect the generator from the battery and from the other generators when enough reverse current exists to damage that generator;

(4) There must be a means to give immediate warning to the flightcrew of a failure of any generator; and

(5) Each generator must have an overvoltage control designed and installed to prevent damage to the electrical system, or to equipment supplied by the electrical system, that could result if that generator were to develop an overvoltage condition.

(d) Instruments. There must be a means to indicate to appropriate flight crewmembers the electric power system quantities essential for safe operation. For direct current systems, an ammeter that can be switched into each generator feeder may be used and if there is only one generator, the ammeter may be in the battery feeder.

(e) Fire resistance. Electrical equipment must be so designed and installed that in the event of a fire in the engine compartment, during which the surface of the firewall adjacent to the fire is heated to 2000° F for 5 minutes or to a lesser temperature substantiated by the applicant, the equipment essential to continued safe operation and located behind the firewall will function satisfactorily and will not create an additional fire hazard.

(f) External power. If provisions are made for connecting external power to the airship, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or a reverse-phase sequence, can supply power to the airship's electrical system.

(g) Electrical/electronic equipment and systems. Each piece of electrical/electronic equipment or systems installed in the airship must be shown through electromagnetic interference and electromagnetic compatibility tests to function properly and not interfere with any other piece of equipment or system aboard the airship.

6.18 Storage battery design and installation.

(a) Each storage battery must be designed and installed as prescribed in this section.

(b) Safe cell temperatures and pressures must be maintained during any probable charging and discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge)—

(1) At maximum regulated voltage or power;

(2) During a flight of maximum duration; and

(3) Under the most adverse cooling condition likely to occur in service.

(c) Compliance with paragraph (b) of this section must be shown by tests unless experience with similar batteries and installations has shown that maintaining safe cell temperatures and pressures presents no problem.

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

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

(f) Each nickel cadmium battery installation capable of being used to start an engine or auxiliary power unit must have provisions to prevent any hazardous effect on structure or essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or of its individual cells.

(g) Nickel cadmium battery installations capable of being used to start an engine or auxiliary power unit must have--

(1) A system to control the charging rate of the battery automatically to prevent battery overheating;

(2) A battery temperature sensing and over-temperature warning system with a means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(3) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

6.19 Circuit protective devices.

(a) Protective devices, such as fuses or circuit breakers, must be installed in all electrical circuits other than--

(1) The main circuits of starter motors; and

(2) Circuits in which no hazard is presented by their omission.

(b) A protective device for a circuit essential to flight safety may not be used to protect any other circuit.

(c) Each resettable circuit protective device ("trip free" device in which the tripping mechanism cannot be overridden by the operating control) must be designed so that—

(1) A manual operation is required to restore service after tripping; and

(2) If an overload or circuit fault exists, the device will open the circuit regardless of the position of the operating control.

(d) If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that circuit breaker or fuse must be so located and identified that it can be readily reset or replaced in flight.

(e) If fuses are used, there must be one spare of each rating, or 50 percent spare fuses of each rating, whichever is greater.

6.20 Master switch arrangement.

(a) There must be a master switch arrangement to allow ready disconnection of electric power sources from the main bus. The point of disconnection must be adjacent to the sources controlled by the switch.

(b) Load circuits may be connected so that they remain energized after the switch is opened, if they are protected by circuit protective devices, rated at five amperes or less, adjacent to the electric power source. These circuits must be isolated, or physically shielded, to prevent their igniting flammable fluids or vapors that might be liberated by the leakage or rupture of flammable fluid systems.

(c) The master switch or its controls must be so installed that the switch is easily discernible and accessible to a crewmember in flight.

6.21 Electric cables and equipment.

(a) Each electric connecting cable must be of adequate capacity.

(b) Each cable and associated equipment that would overheat in the event of circuit overload or fault must be at least flame resistant and may not emit dangerous quantities of toxic fumes.

6.22 Switches.

Each switch must be—

(a) Able to carry it rated current;

(b) Constructed with enough distance or insulating material between current carrying parts and the housing so that vibration in flight will not cause shorting;

(c) Accessible to appropriate flight crewmembers; and

(d) Labeled as to operation and the circuit controlled.

Lights

6.23 Instrument lights.

The instrument lights must—

(a) Make each instrument and control easily readable and discernible;

(b) Be installed so that their direct rays, and any reflections caused directly or indirectly from it are shielded from the pilot's eyes; and

(c) Have enough distance or insulating material between current-carrying parts and the housing so that vibration in flight will not cause shorting.

A cabin dome light is not an instrument light.

6.24 Landing lights.

(a) Each installed landing light must be acceptable.

(b) Each landing light must be installed so that--

(1) No dangerous glare is visible to the pilot;

(2) The pilot is not seriously affected by halation; and

(3) It provides enough light for night landing.

6.25 Position light system installation.

(a) General. Each part of each position light system must meet the applicable requirements of this section and each system as a whole must meet the requirements of §§ 6.26 through 6.31.

(b) Bow position light. The bow position light must be a white light mounted as for forward as possible on the envelope and must be approved.

(c) Forward position lights. Forward position lights must consist of a red and green light spaced laterally as far apart as practicable and installed forward on the airship so that, with the airship in the normal flying position, the red light is on the left side and the green light is on the right side. Each light must be approved.

(d) Rear position light. The rear position light must be a white light mounted as far aft as practicable on the tail and must be approved.

(e) Circuit. The bow position light, the two forward position lights, and the rear position light must make a single circuit.

(f) Light covers and color filters. Each light cover or color filter must be at least flame resistant and may not change color or shape or lose any appreciable light transmission during normal use.

6.26 Position light system dihedral angles.

(a) Except as provided in paragraph (f) of this section, each bow, forward, and rear position light must, as installed, show unbroken light within the dihedral angles described in this section.

(b) Dihedral angle F (forward) is formal by two intersecting vertical planes making angles of 110° to the right and to the left, respectively, to a

vertical plane passing through the longitudinal axis, as viewed when looking forward along the longitudinal axis.

(c) Dihedral angle L (left) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the airship, and the other at 110° to the left of the first, as viewed when looking forward along the longitudinal axis.

(d) Dihedral angle R (right) is formed by two intersecting vertical planes, the first parallel to the longitudinal axis of the airship, and the other 110° to the right of the first, as viewed when looking forward along the longitudinal axis.

(e) Dihedral angle A (aft) is formed by two intersecting vertical planes making angles of 70° to the right and to the left, respectively, to a vertical plane passing through the longitudinal axis, as viewed when looking aft along the longitudinal axis.

(f) If the rear position light, when mounted as far aft as practicable in accordance with § 6.25 (d), cannot show unbroken light within dihedral angle A (as defined in paragraph (e) of this section), a solid angle or angles of obstructed visibility totaling not more than 0.04 steradians is allowable within that dihedral angle, if such solid angle is within a cone whose apex is at the rear position light and whose elements make an angle of 30° with a vertical line passing through the rear position light.

6.27 Position light distribution and intensities

(a) General. The intensities prescribed in this section must be provided by new equipment with each light cover and color filter in place. Intensities must be determined with the light source operating at a steady value equal to the average luminous output of the source at the normal operating voltage of the airship. The light distribution and intensity of each position light must meet the requirements of paragraph (b) of this section.

(b) Bow, forward and rear position lights. The light distribution and intensities of bow, forward, and rear position lights must be expressed in terms of minimum intensities in the horizontal plane, minimum intensities in any vertical plane, and maximum intensities in overlapping beams, within dihedral angles F, L, R, and A, and must meet the following requirements:

(1) Intensities in the horizontal plane. Each intensity in the horizontal plane (a plane containing the longitudinal axis of the airship and perpendicular to the plane of symmetry of the airship) must equal or exceed the values in § 6.28.

(2) Intensities in any vertical plane. Each intensity in any vertical plane (a plane perpendicular to the horizontal plane) must equal or exceed the appropriate value in § 6.29, where I is the minimum intensity prescribed in § 6.28 for the corresponding angles in the horizontal plane.

(3) Intensities in overlaps between adjacent signals. No intensity in any overlap between adjacent signals may exceed the values in § 6.30, except that higher intensities in overlaps may be used with main beam intensities

substantially greater than the minimum specified in § 6.28 and § 6.29, if the overlap intensities in relation to the main beam intensities do not adversely affect signal clarity. When the peak intensity of the forward position lights is more than 100 candles, the maximum overlap intensities between them may exceed the values in § 6.30 if the overlap intensity in Area A is not more than 10 percent of peak position light intensity and the overlap intensity in Area B is not more than 2.5 percent of peak position light intensity.

(c) Bow or rear position light installation. A single-position light may be installed in a position displaced laterally from the plane of symmetry of an airship if—

(1) The axis of the maximum cone of illumination is parallel to the flight path in level flight; and

(2) There is no obstruction aft of the light and between planes 70° to the right and left of the axis of maximum illumination.

6.28 Minimum intensities in the horizontal plane of bow, forward, and rear position lights.

Each position light intensity must equal or exceed the applicable values in the following table:

Dihedral angle (light included)	Angle from right or left of longitudinal axis, measured from dead ahead	Intensity (candles)
F (forward white)	0° to 110°	20
L and R (forward red and green)	0° to 10°	40
	10° to 20°	30
	20° to 110°	5
A (rear white)	110° to 180°	20

6.29 Minimum intensities in any vertical plane of bow, forward, and rear position lights.

Each position light intensity must equal or exceed the applicable values in the following table:

Angle above or below the horizontal plane	Intensity
0°	1.00 I
0° to 5°	0.90 I
5° to 10°	0.80 I
10° to 15°	0.70 I
15° to 20°	0.50 I
20° to 30°	0.30 I
30° to 40°	0.10 I
40° to 90°	0.05 I

6.30 Maximum intensities in overlapping beams of forward and rear position lights.

No position light intensity may exceed the applicable values in the following table, except as provided in § 6.27(b)(3).

Overlaps	Maximum Intensity	
	Area A (candles)	Area B (candles)
Green in dihedral angle L ..	10	1
Red in dihedral angle R	10	1
Green in dihedral angle A ..	5	1
Red in dihedral angle A	5	1
Rear white in dihedral angle L	5	1
Rear white in dihedral angle R	5	1

Where—

(a) Area A includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plan at more than 10° but less than 20°; and

(b) Area B includes all directions in the adjacent dihedral angle that pass through the light source and intersect the common boundary plane at more than 20°.

6.31 Color specifications.

Each position light color must have the applicable International Commission on Illumination chromaticity coordinates as follows:

(a) Aviation red —
"y" is not greater than 0.335; and
"z" is not greater than 0.002.

(b) Aviation green —
"x" is not greater than 0.440-0.320y;
"x" is not greater than y-0.170; and
"y" is not less than 0.390-0.170x.

(c) Aviation white —
"x" is not less than 0.300 and not greater than 0.540;
"y" is not less than "x-0.040" or "y_o-0.010", whichever is the smaller; and
"y" is not greater than "x+0.020" nor "0.636-0.400x";

Where "y_o" is the "y" coordinate of the Planckian radiator for the value of "x" considered.

6.32 Anticollision light system.

(a) General. If certification for night operation is requested, the airship must have an anticollision light system that—

(1) Consists of one or more approved anticollision lights located so that their light will not impair the flight crewmembers' vision or detract from the conspicuity of the position lights; and

(2) Meets the requirements of paragraphs (b) through (f) of this section.

(b) Field of coverage. The system must consist of enough lights to illuminate the vital areas around the airship, considering the physical configuration and flight characteristics of the airship. The field of coverage must extend in each direction within at least 75° above and 75° below the horizontal plane of the airship, except that there may be solid angles of obstructed visibility totaling not more than 0.5 steradians.

(c) Flashing characteristics. The arrangement of the system, that is, the number of light sources, beam width, speed of rotation, and other characteristics, must give an effective flash frequency of not less than 40, nor more than 100, cycles per minute. The effective flash frequency is the frequency at which the airship's complete anticollision light system is observed from a distance, and applies to each sector of light including any overlaps that exist when the system consists of more than one light source. In overlaps, flash frequencies may exceed 100, but not 180, cycles per minute.

(d) Color. Each anticollision light must be either aviation red or aviation white and must meet the applicable requirements of § 6.31.

(e) Light intensity. The minimum light intensities in any vertical plane, measured with the red filter (if used) and expressed in terms of "effective" intensities, must meet the requirements of paragraph (f) of this section. The following relation must be assumed:

$$I_E = \frac{\int_{t_1}^{t_2} I(t)dt}{0.2+(t_2-t_1)} ;$$

Where:

I_E = effective intensity (candles).
$I(t)$ = instantaneous intensity as a function of time.
t_2-t_1 = flash time interval (seconds).

Normally, the maximum value of effective intensity is obtained when t_2 and t_1 are chosen so that the effective intensity is equal to the instantaneous intensity at t_2 and t_1.

(f) Minimum effective intensities for anticollision lights. Each anticollision light effective intensity must equal or exceed the applicable values in the following table.

Angle above or below the horizontal plane:	Effective intensity (candles)
0° to 5°	400
5° to 10°	240
10° to 20°	80
20° to 30°	40
30° to 75°	20

Safety Equipment

6.33 General.

(a) Required safety equipment to be used by the flight crew in an emergency, such as automatic liferaft releases, must be readily accessible.

(b) Stowage provisions for required safety equipment must be furnished and must—

(1) Be arranged so that the equipment is directly accessible and its location obvious; and

(2) Protect the safety equipment from damage caused by being subjected to the inertia loads specified in §3.26.

6.34 Safety belts.

(a) The rated strength of safety belts may not be less than that corresponding with the ultimate load factors specified in § 3.26 considering the dimensional characteristics of the belt installation for the specific seat or berth arrangement.

(b) For safety belts for berths parallel to the longitudinal axis of the airship, the forward load factor specified in § 3.26 need not be applied.

(c) Each safety belt must be equipped with a metal to metal latching device.

6.35 Electrostatic discharge equipment.

A means must be provided for electrostatic discharge during landing and ground handling and while the airship is on the ground.

6.36 Ditching equipment.

If certification with ditching provisions is requested, the airship must meet the requirements of this section.

(a) Emergency flotation and signaling equipment required by the rules under which the airship is operated must be installed so that it is readily available to the crew and passengers.

(b) Each raft and each life preserver must be approved.

(c) Each raft released from the airship must be attached to the airship by a line to keep it near the airship. This line must be designed to break before submerging the empty raft to which it is attached.

(d) Each signaling device required by any operating rule must be accessible, function satisfactorily, and must be free of any hazard in its operation.

6.37 Ice protection equipment.

If certification with ice protection provisions is desired, compliance with the following requirements must be shown:

(a) The recommended procedures for the use of the ice protection equipment must be set forth in the Airship Flight Manual.

(b) An analysis must be performed to establish, on the basis of the airship's operational needs, the adequacy of the ice protection system for the various components of the airship. In addition, tests of the ice protection system must be conducted to demonstrate that the airship is capable of operating safely in continuous maximum and intermittent maximum icing conditions as described in Appendix C of Part 25 of the FAR.

(c) Compliance with all or portions of this section may be accomplished by reference, where applicable because of similarity of the designs, to analysis and tests performed for the type certification of a type-certificated airship.

(d) If night operation is desired and when monitoring of external portions of the airship by the flight crew is required for proper operation of the ice protection equipment, external lighting must be provided which is adequate to enable the monitoring to be done at night.

Miscellaneous Equipment

6.38 Hydraulic systems.

(a) Design. Each hydraulic system must be designed as follows:

(1) Each hydraulic system and its elements must withstand, without yielding, the structural loads expected in addition to hydraulic loads.

(2) A means to indicate the pressure in each hydraulic system which supplies two or more primary functions must be provided to the flight crew.

(3) There must be means to ensure that the pressure, including transient (surge) pressure, in any part of the system will not exceed the safe limit above design operating pressure and to prevent excessive pressure resulting from fluid volumetric changes in all lines which are likely to remain closed long enough for such changes to occur.

(4) The minimum design burst pressure must be 2.5 times the operating pressure.

(b) Tests. Each system must be substantiated by proof pressure tests. When proof tested, no part of any system may fail, malfunction, or experience a permanent set. The proof load of each system must be at least 1.5 times the maximum operating pressure of that system.

(c) Accumulators. No hydraulic accumulator or pressurized reservoir may be installed on the engine side of any firewall, unless it is an integral part of an engine or propeller.

6.39 Accessories for multiengine airships.

For multiengine airships, engine-driven accessories essential to safe operation must be distributed among two or more engines so that the failure of any one engine will not impair safe operation through the malfunctioning of these accessories.

6.40 Pressurization and pneumatic systems.

The following requirements apply to all pressurization and pneumatic systems in the airship except those systems dedicated to the pressurization of the envelope and ballonets.

(a) Pressurization system elements must be burst pressure tested to 2.0 times, and proof pressure tested to 1.5 times, the maximum normal operating pressure.

(b) Pneumatic system elements must be burst pressure tested to 3.0 times, and proof pressure tested to 1.5 times, the maximum normal operating pressure.

(c) An analysis, or a combination of analysis and test may be substituted for any test required by paragraph (a) or (b) of this section if the Administrator finds it equivalent to the required test.

6.41 Equipment containing high energy rotors.

(a) Equipment containing high energy rotors must meet paragraph (b), (c), or (d) of this section.

(b) High energy rotors contained in equipment must be able to withstand damage caused by malfunctions, vibration, abnormal speeds, and abnormal temperatures. In addition—

(1) Auxiliary rotor cases must be able to contain damage caused by the failure of high energy rotor blades; and

(2) Equipment control devices, systems, and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high energy rotors will be exceeded in service.

(c) It must be shown by test that equipment containing high energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative.

(d) Equipment containing high energy rotors must be located where rotor failure will neither endanger the occupants nor adversely affect continued safe flight.

SUBPART VII - OPERATING LIMITATIONS AND INFORMATION

7.1 General.

(a) Each operating limitation specified in §§ 7.2 through 7.11 and other limitations and information necessary for safe operation must be established.

(b) The operating limitations and other information necessary for safe operation must be made available to the crewmembers as prescribed in §§ 7.13 through 7.29.

Operating Limitations

7.2 Airspeed limitations.

(a) The maximum operating limit speed, V_{MO}, must be established as a speed that may not be deliberately exceeded in any regime of flight (climb, cruise, or descent). V_{MO} must be established so that it is not greater than V_H.

(b) The maximum landing gear operating speed, V_L, may not exceed the speed determined under § 4.25 or by flight characteristics.

7.3 Weight and center of gravity.

The weight and center of gravity limitations determined under § 2.2 must be established as operating limitations. This includes the maximum takeoff weight, maximum landing weight, maximum car weight, and maximum permissible static heaviness and static lightness.

7.4 Powerplant limitations.

(a) General. The powerplant limitations prescribed in this section must be established so that they do not exceed the corresponding limits for which the engines or propellers are either approved or type certificated.

(b) Takeoff operation. The powerplant takeoff operation must be limited by—

(1) The maximum rotational speed (r.p.m.);

(2) The maximum allowable manifold pressure (for reciprocating, altitude engines);

(3) The maximum allowable gas temperature (for turbine engines);

(4) The time limit for the use of the power or thrust corresponding to the limitations established in subparagraphs (1) through (3) of this paragraph; and

(5) If the time limit in subparagraph (4) of this paragraph exceeds 2 minutes, the maximum allowable cylinder head (as applicable), oil, and liquid coolant temperatures.

(c) Continuous operation. The continuous operation must be limited by—

(1) The maximum rational speed;

(2) The maximum allowable manifold pressure (for reciprocating, altitude engines);

(3) The maximum allowable gas temperature (for turbine engines); and

(4) The maximum allowable cylinder head (as applicable), oil, and liquid coolant temperatures.

(d) Fuel grade or designation. The minimum fuel grade (for reciprocating engines) or fuel designation (for turbine engines) must be established so that it is not less than that required for the operation of the engines within the limitations of paragraphs (b) and (c) of this section.

(e) Ambient temperature. For turbine engines, ambient temperature limitations (including limitations for winterization installations if applicable) must be established as the maximum ambient atmospheric temperature at which compliance with the cooling provisions is shown.

7.5 Auxiliary power unit limitations.

If an auxiliary power unit is installed in the airship, the limitations established for that auxiliary power unit must be specified as operating limitations for the airship. These operating limitations must include, at least, the following:

(a) Maximum speed for the gas producer of turbine engines.

(b) Maximum temperatures for overtemp protection for turbine engines.

(c) Maximum speed for reciprocating engines.

(d) Maximum cylinder head temperature for air-cooled reciprocating engines.

7.6 Minimum flight crew.

The minimum flight crew must be established so that it is sufficient for safe operation considering—

(a) The workload on individual crew members;

(b) The accessibility and ease of operation of necessary controls by the appropriate crew members; and

(c) The kinds of operation authorized under § 7.8.

7.7 Maximum passenger-seating configuration.

The maximum passenger-seating configuration must be established.

7.8 Kinds of operation.

The kinds of operation to which the airship is limited are established by the category in which it is eligible for certification and by the installed equipment.

7.9 Maximum rates of ascent and descent.

The maximum rates of ascent and descent determined under § 2.8(b) must be established.

7.10 Engine vectoring.

The maximum engine vectoring angles, both up and down, to which operation is allowed, as limited by flight, structural, powerplant, and functional requirements, must be established.

7.11 Envelope and ballonet pressures.

Operating pressure limitations for the envelope and ballonets, as limited by flight, structural, and functional, must be established, and must include the following:

(a) Maximum and minimum operating pressure in the envelope.

(b) Maximum operating pressure in the ballonets.

7.12 Instructions for continued airworthiness.

The applicant must prepare Instructions for Continued Airworthiness in accordance with Appendix G to Part 23 of the FAR, as appropriate, that are acceptable to the Administrator. The instructions may be incomplete at type certification if a program exists to ensure their completion prior to delivery of the first airship or issuance of a standard certificate of airworthiness whichever occurs later.

Markings and Placards

7.13 General.

(a) The airship must contain--

(1) The specified markings and placards; and

(2) Any additional information, instrument markings, and placards required for the safe operation of the airship.

(b) Each marking and placard prescribed in paragraph (a) of this section--

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

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

7.14 Instrument markings; general.

For each instrument--

(a) When markings are on the cover glass of the instrument, there must be means to maintain the correct alignment of the glass cover with the face of the dial;

(b) Each arc and line must be wide enough and located to be clearly visible to the pilot; and

* (c) When digital instruments are used, an analog trend indication must be provided unless, it is determined that the trend indicator advantages of an analog indicator are not needed. The limiting values must be marked on the analog indicator, if an analog indicator is needed. *

7.15 Airspeed indicator.

There must be a radial red line marking for V_{MO} made at the lowest value of V_{MO} established for any altitude up to the maximum operating altitude for the airship.

7.16 Magnetic direction indicator.

(a) A placard meeting the requirements of this section must be installed on or near the magnetic direction indicator;

(b) The placard must show the calibration of the instruments in level flight with the engines operating;

(c) The placard must state whether the calibration was made with radio receivers on or off;

(d) Each calibration reading must be in terms of magnetic heading in not more than 30° increments.

(e) If a magnetic nonstabilized direction indicator can have a deviation of more than 10 degrees caused by the operation of electrical equipment, the placard must state which electrical loads, or combination of loads, would cause a deviation of more than 10 degrees when turned on.

7.17 Powerplant and auxiliary power unit instruments.

For each required powerplant and auxiliary power unit instrument, as appropriate to the type of instrument—

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each takeoff and precautionary range must be marked with a yellow arc or a yellow line; and

(d) Each engine, auxiliary power unit, or propeller speed range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.

7.18 Oil quantity indicator.

Each oil quantity indicator must be marked in sufficient increments to indicate readily and accurately the quantity of oil.

7.19 Fuel quantity indicator.

If the unusable fuel supply for any tank exceeds 1 gallon, or 5 percent of the tank capacity, whichever is greater, a red arc must be marked on its indicator extending from the calibrated zero reading to the lowest reading obtainable in level flight.

7.20 Control markings.

(a) Each cockpit control, other than primary flight controls and controls whose function is obvious, must be plainly marked as to its function and method of operation.

(b) Each secondary control must be suitably marked.

(c) For powerplant fuel controls—

(1) Each fuel tank selector control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;

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

(3) The conditions under which the full amount of usable fuel in any restricted usage fuel tank can safely be used must be stated on a placard adjacent to the selector valve for that tank; and

(4) Each valve control for any engine of a multiengine airship must be marked to indicate the position corresponding to each engine controlled.

(d) Usable fuel capacity must be marked as follows:

(1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated at the fuel quantity indicator.

(2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

(e) For accessory, auxiliary, and emergency controls—

(1) If retractable landing gear is used, the indicator required by § 4.25(e) must be marked so that the pilot can, at any time, ascertain that the wheels are secured in the extreme positions; and

(2) Each emergency control must be red and must be marked as to method of operation.

7.21 Miscellaneous markings and placards.

(a) Baggage and cargo compartments, and ballast location. Each baggage and cargo compartment, and each ballast location, must have a placard stating any limitations on contents, including weight, that are necessary under the loading requirements.

(b) Seats. If the maximum allowable weight to be carried in a seat is less than 170 pounds, a placard stating the lesser weight must be permanently attached to the seat structure.

(c) Fuel and oil filler openings. The following apply:

(1) Fuel filler openings must be marked at or near the filler cover with—

(i) The word "fuel"

(ii) For reciprocating engine-powered airships, the minimum fuel grade;

(iii) For turbine engine-powered airships, the permissible fuel designations; and

(iv) For pressure fueling systems, the maximum permissible fueling supply pressure and the maximum permissible defueling pressure.

(2) Oil filter openings must be marked at or near the filler cover with the word "oil," the oil capacity, and the approved grade and specification of oil.

(d) Emergency exit placards. Each placard and operating control for each emergency exit must be red. A placard must be near each emergency exit control and must clearly indicate the location of that exit and its method of operation.

(e) The system voltage of each direct current installation must be clearly marked adjacent to its external power connection.

(f) Unusable fuel. If the unusable fuel supply in any tank exceeds 5 percent of the tank capacity, or 1 gallon, whichever is greater, a placard must be installed next to the fuel quantity indicator for that tank, stating that the fuel remaining when the quantity indicator reads "zero" in level flight cannot be used safely in flight.

7.22 Operating limitations placard.

There must be a placard in clear view of the pilot that specifies the kind of operations (such as VFR, IFR, day, or night) and meteorological conditions (such as icing conditions) to which the operation of the airship is limited, or from which it is prohibited, by the equipment installed.

7.23 Safety equipment.

(a) Safety equipment must be plainly marked as to method of operation.

(b) Stowage provisions for required safety equipment must be marked for the benefit of the occupants.

7.24 Airspeed placard.

There must be an airspeed placard in clear view of the pilot and as close as practicable to the airspeed indicator. This placard must list the maximum landing gear operating speed V_L.

Airship Flight Manual

7.25 General.

* (a) Furnishing information. An Airship Flight Manual and an Airship Ground Handling Manual, for ground handling procedures, must be furnished with each airship, and they must * contain the following:

(1) Information required by §§ 7.26 through 7.29.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) Approved information.

(1) Except as provided in subparagraph (b)(2) of this section, each part of the Airship Flight Manual containing information prescribed in §§ 7.26 through 7.29 must be approved, segregated, identified, and clearly distinguished from each unapproved part of that manual.

(2) The requirements of subparagraph (b)(1) of this section do not apply if the following is met:

(i) Each part of the Airship Flight Manual containing information prescribed in § 7.26 must be limited to such information, and must be approved, identified, and clearly distinguished from each other part of the Airship Flight Manual.

(ii) The information prescribed in §§ 7.27 through 7.29 must be determined in accordance with the applicable requirements of this criteria and presented in its entirety in a manner acceptable to the Administrator.

(3) Each page of the Airship Flight Manual containing information prescribed in this section must be of a type that is not easily erased, disfigured, or misplaced, and is capable of being inserted in a manual provided by the applicant, or in a folder, or in any other permanent binder.

(c) Each Airship Flight Manual must include a table of contents if the complexity of the manual indicates a need for it.

7.26 Operating Limitations.

(a) Airspeed limitations. The following information must be furnished:

(1) The maximum operating limit speed, V_{MO}, and a statement that this speed limit may not be deliberately exceeded in any regime of flight (climb, cruise, or descent) unless a higher speed is authorized for flight test or pilot training.

(2) The landing gear operating speed.

(b) Powerplant limitations. The following information must be furnished:

(1) Limitations required by § 7.4.

(2) Explanation of the limitations, when appropriate.

(3) Information necessary for marking the instruments required by §§ 7.17 through 7.19.

(c) Weight. The Airship Flight Manual must include the following weight limitations:

(1) Maximum weight (takeoff).

(2) Maximum landing weight.

(3) Maximum permissible static heaviness and static lightness.

(4) Maximum car weight.

(5) Maximum baggage compartment weights.

(d) Center of gravity. The established center of gravity limits must be furnished.

(e) Flight crew. The minimum crew required must be stated and if more than one is required for safety, the number and functions of the minimum flight crew must be furnished.

(f) Kinds of operation. The kinds of operation (such as VFR, IFR, day, or night) and the meteorological conditions under which the airship may or may not be used, must be furnished. Installed equipment that affects any operating limitation must be listed and identified as to its operational function.

(g) Maximum passenger seating configuration. The maximum passenger seating configuration must be furnished.

(h) Envelope pressure. The minimum and maximum envelope and ballonet pressures must be furnished.

(i) Maximum rates of ascent and descent. The maximum rates of ascent and descent must be furnished.

(j) Maneuvers. The maximum pitch angles for the airship must be furnished.

(k) Placards. Any placards which are required by §§ 7.13 through 7.24 must be reproduced together with a written description of the appropriate locations of each on the airship.

7.27 Operating procedures.

(a) For each airship, information concerning normal and emergency procedures and other pertinent information necessary for safe operation must be furnished, including--

(1) The recommended climb speed and any variation with altitude;

(2) The recommended takeoff and climb profiles including use of auxiliary thrust, lift, and trim controls, and power management for normal takeoff and climb as well as for short field operations, if different;

(3) The recommended approach and landing speeds and profiles including use of auxiliary thrust, lift and trim controls and power management for normal approach and landing as well as for short field operations, if different;

(4) The recommended balked landing climb airspeeds and procedures for transitioning from approach and landing to the balked landing climb;

(5) The recommended procedures for transitioning from powered flight to free balloon mode and associated descent and landing procedures in the free balloon mode;

(6) Operational procedures for maintaining envelope pressures based on the requirements of § 2.20;

(7) Instructions covering the use of control system locks, when used;

(8) Flammable fluid fire protection instructions and procedures based on the requirements of § 4.40;

(9) The recommended procedures for starting and stopping engines as required by § 5.2(d) and (e);

(10) Ditching instructions and procedures (including the procedures based on the requirements of §§ 4.36(b), 6.33, and 6.36);

(11) Instructions and procedures covering the use of ice protection equipment required by § 6.37; and

(12) Instructions and procedures covering the use of fuel jettisoning equipment, including any operating precautions relevant to the use of the system.

* (13) The recommended ground handling, mast handling, and mooring procedures required by § 2.21. These procedures will reflect the design capabilities of the airship as required by § 3.25. *

(14) Operational procedures covering ballast disposal based on the requirements of § 4.49.

(15) Operational procedures covering fuel jettisoning based on the requirements of § 5.30.

* (16) Operational procedures covering the emergency evacuation based on the requirements of § 4.43(g). *

(b) For multiengine airships, the following information and procedures must also be included:

(1) Normal and emergency procedures for single engine operations and all engine out operations.

(2) Procedures for obtaining the best performance with one engine inoperative including the effects of various configurations of the airship, prop and auxiliary thrust and lift controls.

(3) Procedures for takeoff determined in accordance with § 2.7.

(4) Information identifying each operating condition in which the fuel system independence prescribed in § 5.9 is necessary for safety must be furnished, together with instructions for placing the fuel system in a configuration used to show compliance with that section.

(c) For each airship showing compliance with § 6.18(g), the operating procedures for disconnecting the battery from its charging source must be furnished.

(d) If the unusable fuel supply in any tank exceeds 5 percent of the tank capacity, or 1 gallon, whichever is greater, information must be furnished which indicates that when the fuel quantity indicator reads "zero" in level flight, any fuel remaining in the fuel tank cannot be used safely in flight.

(e) Information on the total quantity of usable fuel for each fuel tank must be furnished.

7.28 Performance information.

(a) For each airship, the following information must be furnished:

(1) Any loss of altitude more than 100 feet, or any pitch angle more than 30 degrees, occurring during the recovery prescribed in § 2.12.

(2) The conditions under which the full amount of usable fuel in each tank can safely be used.

(3) The takeoff distance determined under § 2.7, the airspeed at the 50-foot height, the airship configuration (if pertinent), the kind of surface in the tests, and the pertinent information with respect to cowl flap position, use of flight path control devices, and use of the landing gear retraction system.

(4) The landing distance determined under § 2.10, the airship configuration (if pertinent), and the kind of surface used in the tests.

(5) The steady rate or gradient of climb determined under §§ 2.8 and 2.12, the airspeed, power, and the airship configuration.

(6) The calculated approximate effect on takeoff distance (paragraph (a)(3) of this section), landing distance (paragraph (a)(4) of this section), and steady rates of climb (paragraph (a)(5) of this section), of variations in—

(i) Altitude from sea level to maximum design takeoff altitude;

(ii) Temperature at these altitudes from 60 degrees F below standard to 40 degrees F above standard;

(iii) Relative humidity at these altitudes from 20 percent to 100 percent; and

(iv) Lifting gas purity.

(7) For reciprocating engine-powered airships, the maximum atmospheric temperature at which compliance with the cooling provisions of §§ 5.39 through 5.41 is shown.

(b) For multiengine airships, the following information must be furnished:

(1) The best rate of climb speed with one engine inoperative.

(2) The speed used in showing compliance with the cooling and climb requirements of § 5.41(e)(2)(iv), if this speed is greater than the best rate of climb speed with one engine inoperative.

(3) The steady rate or gradient of climb determined under § 2.9 and the airspeed, power, and airship configuration.

(4) The calculated approximate effect on the climb performance determined under § 2.9 of variations in—

(i) Altitude from sea level to maximum design altitude;

(ii) Temperature at these altitudes from 60 degrees F below standard to 40 degrees F above standard;

(iii) Relative humidity at these altitudes from 20 percent to 100 percent; and

(iv) Lifting gas purity.

7.29 Loading information.

The following loading information must be furnished:

(a) The weight and location of each item of equipment included in the empty weight as determined under § 2.4.

(b) Appropriate loading instructions for each possible loading condition between the maximum and minimum weights determined under § 2.3 that can result in a center of gravity beyond—

(1) The extremes selected by the applicant;

(2) The extremes within which the structure is proven; or

(3) The extremes within which compliance with each functional requirement is shown.

APPENDIX A. TEARING STRENGTH

1. SCOPE.

1.1 This method is intended for use in determining the tearing strength of envelope fabric.

2. SPECIMEN.

2.1 The sample must consist of a 4 inches by 6 inches sample having a 1-1/4 inch wide slit made with a razor blade across the center of the sample at right angles to the longest dimension. (Figure 1)

3. APPARATUS.

3.1 The apparatus must be specified for Method 5100 of Federal Requirement 191A "Textile Test Methods."

4. PROCEDURES.

4.1 The specimen must be placed symmetrically in the clamps of the machine with the long dimension parallel and the short dimension at right angles to the direction of application of the load. The yarn running parallel to the long dimension must be aligned parallel with one outside edge of the front jaw of each clamp to ensure the same yarns being gripped in both clamps. The clamps must be 1 inch wide and must grip the yarns that have been slit.

4.2 The distance between clamps must be 3 inches at the start of the test, with the slit in the specimen an equal distance from each clamp jaw.

4.3 Breaking force must be applied to the specimen at such a rate that the pulling clamp will travel at a uniform speed of 12.0 $\pm$ 0.5 inches per minute. After rupture of the specimen, the breaking force must be read from the dial, scale, or chart and the value recorded. Five specimens in both the warp and woof (fill) directions must be tested and results reported for each fabric type.

5. RESULT.

5.1 The tearing strength is determined as the average load, in pounds, of the highest recorded peaks of the five specimens.

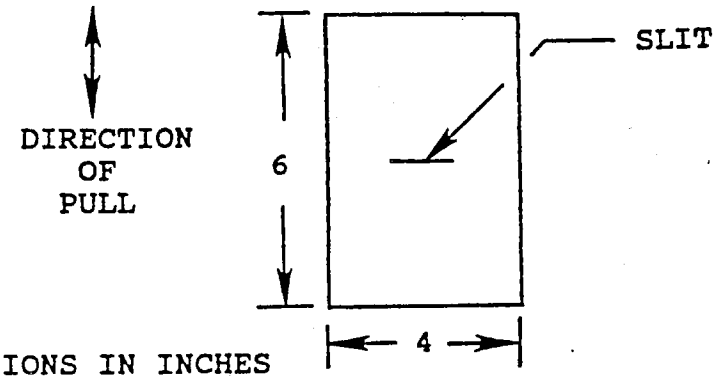

FIGURE 1 - SAMPLE SPECIMEN

APPENDIX B. EXPLANATION OF CHANGES

1. Paragraph 2.4(b). This paragraph provides for the condition of the airship while determining its empty weight. The requirement specifies that the airship weighing can be repeated. There may be some confusion as to the intent of the requirement after airship erection. The intent is to provide an acceptable weight control program that would produce repeatable results whenever the airship is deflated. This paragraph has been rewritten to clarify the intent.

2. Paragraph 3.9. This paragraph provides for the loads resulting from encounters with prescribed atmospheric gusts while the airship is in level flight. There has been some concern over both the magnitude of the specified gusts and the equation that may be used to compute the maximum aerodynamic bending moment from these gusts.

The FAA believes that the current gust velocities provide a level of safety consistent with that required by § 21.17(b) of the Federal Aviation Regulations (FAR). Therefore, the gusts defined in paragraph 3.9(a) were retained without revision.

In paragraph 3.9(c), an equation was provided to compute the maximum aerodynamic bending moment based on the gust intensities of paragraph 3.9(a). This equation must be used in the absence of a more rational analysis. It was determined that the equation presented in the ADC was intended to be used for rigid airship hull structures, and, therefore was not appropriate for nonrigid airships. Loral (Goodyear) proposed other equations that would have been appropriate for nonrigid airships. One of these was used in a proposal to the U.S. Navy, and was used here. Paragraph 3.9(c) has been rewritten to provide a design equation that reflects the above discussion.

3. Paragraph 3.25. The requirements specify a maximum wind velocity of 78 knots while the airship is attached to the mast. There has been some concern over the magnitude of this wind speed as a minimum design requirement. It was used by the Navy in their design requirements to permit mooring in the vicinity of severe thunderstorms. Hurricanes were not a consideration in the development of this requirement. Successful civil airship operation conducted in the United States has indicated that 70

knots is an adequate design requirement. It is not expected that civil airships would be exposed to severe thunderstorms like the naval airships were designed for. Therefore, this requirement has been reduced to 70 knots.

Another aspect of the above condition which is associated with a sudden change in the wind velocity or a sudden let-up of the wind. The FAA proposed to specify the need to investigate the compressive loads caused by the elastic response to the airship to an extreme, sudden change in wind velocity. Slight envelope wrinkling at the ends of the battens may be permitted. This may be applicable to all mooring and handling conditions that cause compressive loads at the battens.

The unsymmetrical mooring condition is similar to the symmetrical mooring condition but accounts for an instantaneous wind shift (airship has not had time to react) to either side. This wind condition applies to all of the conditions except symmetrical mooring and mast handling-override. Based on previously conducted experiments, the critical loads usually occur when the wind angle is between 10 degrees and 15 degrees.

The mast handling conditions pertain to airship handling while attached to a mobile mast. The override condition is based on the situation where the mobile mast stops suddenly while traveling at 3 knots. This condition provides a compressive load between the mast and the airship. The wind velocity is assumed equal to zero. There was some concern that this condition was not appropriate. The FAA disagrees. Section Q of the BCAR has a similar requirement as a result of British experience with their airships. Mast handling conditions would not be applicable if their use was specifically prohibited in the operating and handling limitations.

Some of the notes for Table 4 were written incorrectly and needed to be revised.

This paragraph has been rewritten to provide design conditions that reflect the above discussion.

4. Paragraph 3.26(b). This paragraph provides for the ultimate inertia forces necessary to ensure the safety of the occupants during a minor crash landing. Since there are no tests or data directly correlating operational experience to values for ultimate inertia forces, the values specified in the ADC were based on the Navy specifications. A review of the Navy accident data does not contain much detail; however, it appears that crew

members were able to remain at their stations, without restraints or severe injury, throughout the accidents as long as they desired to do so. Based on the above discussion, the FAA believes that the values listed in the ADC were excessive.

The table in subparagraph 3.26(b)(2) has been rewritten to provide design requirements that reflect a more realistic viewpoint of minor crash landing conditions.

5. Paragraph 4.19(c). This paragraph provides for a 3 second delay time for recognition of a failure in the nonmechanical flight control system. This requirement follows closely a similar requirement for fixed wing aircraft. Based upon the relatively slow response of an airship to a control input, this delay time is not appropriate.

The paragraph has been rewritten to remove this requirement.

6. Paragraph 4.28(c). This paragraph contains an incorrect word. This paragraph has been rewritten to correct the text by replacing "or" in the second line with "of."

7. Paragraph 4.43(a). This paragraph provides for the envelope to be pressurized so as to remain in tension while supporting the limit design loads for all flight conditions. Ground handling conditions were not considered. The current revision to paragraph 3.25 provides clarification to some of the mooring and handling conditions. The explanation material for this revision suggests that envelope wrinkling be permitted at the ends of the battens during mooring and handling conditions. This paragraph needs to provide for this unique envelope behavior during these conditions.

This paragraph has been rewritten to define envelope limitations during mooring conditions.

8. Paragraph 4.43(g). This paragraph provides for the emergency deflation of the envelope while on the ground. It specifies that the deflation rate must be consistent with the time allowed for occupant evacuation which is 90 seconds. There has been some objection to the time limit.

The intent of the requirement is to enhance the emergency evacuation of the airship. That is, during evacuation, the airship should not leave the ground to an extent that would prevent the occupants leaving, and the envelope should not fall prematurely, entrapping the occupants. The time quoted reflects

that for transport category aircraft. The British BCAR Section Q specifies 60 seconds. Section 21.17(b) requires a level of safety for airships that is equivalent to that provided by the appropriate airworthiness standards listed in Subchapter C of CFR 14. The appropriate regulation is Part 23 of the FAR which does not specify a time limit for emergency evacuation. Therefore, a time limit for airships having a capacity of nine seats or less, excluding crew, may be requiring a higher level of safety than intended.

The paragraph has been rewritten to emphasize the need to keep the airship on the ground and to prevent the envelope from falling on the occupants as they evacuate the airship.

9. Paragraph 4.44(a). This paragraph requires the helium valve to be located below the equator. There was concern expressed that helium valves located on the bottom of the envelope would be limited in their ability to discharge helium under emergency conditions. Helium valve locations were required below the equator to provide ready access for inspection, maintenance, protection from accumulating moisture, and to keep the valves out of the envelope compression area. Experience has shown that valves located on the side of the envelope function adequately. The FAA believes that helium valves located a small distance above the equator would not detract from the above stated objectives. This would slightly increase the location options for the designer without detracting from safety.

The second sentence has been rewritten to increase the acceptable locations for helium valves.

10. Paragraph 4.44(d). This paragraph provides for the ability to maintain envelope pressure after the failure of all engines for sufficient time to make a landing. There was some concern about a need for the requirement and the interpretation of "sufficient." The intent was to accommodate the systems dependent upon the envelope shape. The FAA believes that maintaining the envelope shape is desirable. Therefore, the emphasis of the last sentence of this paragraph should be placed on the envelope shape and not on the pressure.

The last sentence of the paragraph has been rewritten to clarify this intent.

11. Paragraph 4.45. This paragraph contains the requirement to provide ground handling procedures in the airship flight manual. This requirement is more appropriately listed in paragraph 7.27.

The last sentence has been rewritten to improve the organization of the Airship Design Criteria.

12. Paragraph 5.54(a). This paragraph requires a separate vector control for each engine. This requirement is based on the philosophy that each engine must be controllable independently of all other engines. There was some concern over the need to have separate vector controls. The FAA agrees that there is no need for independent engine vectoring, and that it may actually be undesirable. However, independent engine vectoring will be retained as an option.

Paragraphs 5.54 and 5.62 have been rewritten to clarify thrust vectoring and provide design options.

13. Paragraph 6.4(e). This paragraph provides for a relative position indicator, a comparator warning system, and a failure warning system for a fly-by-wire flight control system. These requirements were patterned after the requirements established for similar equipment installed in fixed-wing aircraft. Because of the slower response of airships. there was concern that some of the requirements may not be appropriate. The first requirement provides a means to determine that the fly-by-wire system is accomplishing its intended function. For example, when the control is moved to full pitch up position, the means should indicate that the control surfaces have actually achieved that position. Concerning the second requirement, due to the airship's slow response, the FAA considers this requirement unnecessary. Concerning the third requirement, the airship's response time is not pertinent. The FAA believes that the first and third requirements are appropriate and should be retained.

To relieve the applicant from an unnecessary burden, the second requirement has been removed, and the third requirement has been relabelled.

14. Paragraph 6.7(d). This paragraph requires that the airship in all conditions have their instruments in the basic T configuration. Since the response time of an airship is

relatively slow as compared to an airplane, in which the basic T configuration is required, it is unnecessary for an airship, limited to VFR conditions, to have the basic T configuration instrument arrangement.

This paragraph has been rewritten to allow for other configurations when limited to VFR conditions.

15. Paragraph 6.9(b). The requirement of paragraph 6.9(b) of the ADC is unnecessarily restrictive, given the requirements of Section 23.1323 of part 23 of the FAR. An airship is less dependent on airspeed indication than fixed wing airplanes; therefore, the accuracy requirements should not exceed those for part 23 airplanes.

We have revised this paragraph to reflect this comment.

16. Paragraph 6.10(b)(3). This requirement should only apply to those airships which are to be operated under Instrument Flight Rules or in icing conditions.

The first sentence has been revised to reflect this comment.

17. Paragraph 7.14(c). This requirement states that an analog trend indication must be provided when digital instruments are used. An analog trend indicator is not always necessary when it can be justified in using digital instruments, if the rate of change is so slow that the trend monitoring advantages of an analog indicator are not needed.

This paragraph has been rewritten, where trend monitoring is not an advantage, to allow for installation of a digital instrument monitoring slow rates of change.

18. Paragraph 7.25(a). This paragraph provides for an Airship Flight Manual that contains required information for the flight crew. This information includes that concerning ground handling procedures which may have little value for the flight crew. Ground handling provides a significant portion of the environment of an airship. Therefore, it is necessary that ground handling information be provided in a clear and concise manner. An Airship Ground Handling Manual is the recommended means to provide this information.

The first sentence of paragraph 7.25(a) has been rewritten to provide for an Airship Ground Handling Manual.

19. Paragraph 7.27(a). Subparagraph (13) provides for the operating procedures for ground handling and mooring. There isn't any specified connection between these procedures and the design requirements of paragraph 3.25. The design capabilities of the airship need to be reflected in its operating procedures.

To ensure that the operating procedures reflect the design capabilities of the airship, subparagraph (13) has been rewritten.

This paragraph also provides for both normal and emergency operating procedures to be included in the airship flight manual. There is a need to provide information to the crew concerning the emergency evacuation of the airship. Paragraph 4.43(g) provides for a means to deflate the envelope to enhance emergency evacuation. A procedure must be established to meet this objective while maintaining the specified objectives of keeping the airship on the ground, and not permitting the envelope to deflate so rapidly so as to entrap the occupants.

To provide for an operating procedure for emergency evacuation, paragraph 7.27(a) has been amended by adding a new subparagraph (16).

NOTE: Paragraphs numbered 14 through 17 were coordinated under proposed change 1. A notice of availability with request for comments was published in the Federal Register on June 15, 1989. Comments were received; however, change 1 was never published.

All other paragraphs were coordinated under proposed change 2. A notice of availability with request for comments on proposed change 2 was published in the Federal Register on February 4, 1992. *