CIVIL AIR REGULATIONS

PART 7

ROTORCRAFT AIRWORTHINESS
TRANSPORT CATEGORIES

EFFECTIVE AUGUST 1, 1956

CIVIL
AERONAUTICS BOARD

WASHINGTON, D. C.

(Reprinted from Federal Register dated June 2, 1956)

PART 7—ROTORCRAFT AIRWORTHINESS; TRANSPORT CATEGORIES

CIVIL AIR REGULATIONS

Adopted by the Civil Aeronautics Board at its office in Washington, D.C., on the 25th day of May 1956.

Until the present time, all of the effective airworthiness requirements for rotorcraft were contained in Part 6 of the Civil Air Regulations. These requirements were based mainly upon experience with rotorcraft of relatively small size, and very little distinction was made between large and small rotorcraft or between rotorcraft intended for general and air carrier service.

Since the adoption of Part 6 the size and complexity of rotorcraft equipment have grown, and with each new design development in this field an attempt was made to accommodate the changes within the framework of Part 6. This became more difficult to do because when catering to the larger and more complicated rotorcraft the airworthiness provisions for smaller, more basic, rotorcraft became unnecessarily complex. Therefore, it has become apparent that the existing regulations in Part 6 are not suitable for the certification requirements applicable to both large and small rotorcraft and rotorcraft to be utilized in the transport category class require a set of provisions peculiar to their needs.

In recognition of this situation, the Board, in recent years, has conducted studies with the view to establishing airworthiness requirements for large rotorcraft which are intended to be used in air carrier service. These studies have resulted in a categorization of rotorcraft with corresponding airworthiness requirements. The three categories being established are the "Normal Category" for rotorcraft of 6,000 pounds or less maximum weight "Transport Category A" for multiengine rotorcraft of unlimited weight, and "Transport Category B" for single or multiengine rotorcraft of 20,000 pounds or less maximum weight. Rotorcraft certificated in either of the transport categories will be eligible for operations in either scheduled or irregular passenger or cargo service.

Concurrently with the adoption of this new Part 7, the Board i adopting amendments to Part 6 of the Civil Air Regulations whic make the part applicable to small rotorcraft in the normal cate and which simplify and clarify the requirements for certificati such rotorcraft.

In the development of Part 7, consideration was given to the problem of whether specific airworthiness requirements for la rotorcraft should be adopted prior to obtaining significant op experience in such rotorcraft types, or whether the considera of the design of large transport category rotorcraft required a determination of at least the broad objective standards for certification of such large rotorcraft. It is to be desired, and i Board's general policy, to have the benefit of experience in a of adoption of regulations. However, much can be gained by initially establishing broad objective standards and giving th Administrator wide discretion in approving features of desig which were not anticipated. Therefore, the Board considers i desirable to promulgate such standards at this time in the beli safe operations are most assured where basic standards have established.

After determining that the provisions of Part 6 were not suitable for the certification of large multiengine transport cat rotorcraft, and after completion of the aforementioned studies notice of proposed rule making (20 F. R. 3114) was circulated Civil Air Regulation Draft Release No. 55-11 to solicit comment o the proposed categorization of rotorcraft.

Comments received on the subject were almost universall favorable to the board's adopting objective standards immediately so that the design and construction of large rotorcraft could proceed under some pattern of uniformity. The comment of one industry observer, however, while acknowledging that experience gained with transport category airplanes could provide guideposts for developing regulations for rotorcraft airworthiness in areas such as structures, design, and construction, nevertheless, expressed reservation as to whether performance requirements could be prepared on the same basis since there was insufficient operational experience with the types of rotorcraft envisaged in the transport category classes.

In recognition of this valid comment, and because the Board does not intend to limit novel design features or operating techniques which may prove advantageous, the performance specifications in this part are limited in general to requirements for the scheduling of performance data. There are included, however, two quantitative requirements: One is the minimum one-engine-inoperative climb for Transport Category A rotorcraft; and the other, a minimum hovering ceiling for Transport Category B rotorcraft. These climb requirements are expressed in terms of rates of climb. Among the comments received on the proposal were recommendations that these minima be expressed in terms of gradient of climb. While this recommendation has substantial merit, it is considered advisable to retain the more familiar expression for the present and to study the matter at the next Annual Airworthiness Review, since consideration of factors of minimum speed or acceleration may be necessary. It is considered that for the time being the two quantitative requirements are reasonable minima. However, in order to define more fully the level of performance for the rotorcraft, it will be necessary to implement the performance data scheduled under this part with operating limitations relating to the measured performance of the rotorcraft, the dimensions of the heliport used, the adjacent obstacles, and the routes traversed. Because it is considered desirable to obtain experience in the operation of transport category rotorcraft before establishing by regulation specific operating limitations, it is contemplated that in the interim, for air carrier operations and for other operations over highly congested areas, the Administrator will determine that the operations in question are limited in such a manner as to assure a safe operation. Performance operating limitations will, however, be developed and included in the Civil Air Regulations as rapidly as the state of the art permits.

In considering this part, a maximum weight limitation had to be established for Transport Category B rotorcraft. The limit set in the notice of proposed rule making was 17,500 pounds. This limit has been raised to 20,000 pounds upon advice that some manufacturers now have design studies for single-engine rotorcraft which are expected to go over 17,500 pounds. This weight limit appears adequate to assure safety to all Transport Category B rotorcraft and is sufficiently high to include all reported single-engine designs now being developed by the manufacturers.

Another important problem to which the Board gave particular consideration is that of fire protection for structures, controls, and other components of the rotorcraft. The fire protection requirements for Transport Category A rotorcraft are intended to permit extinguishment of a fire and the continuation of the flight to a suitable airport. The Category B requirements, on the other hand, are intended to protect the rotorcraft and its occupants during an immediate descent and landing. The difference in the requirements is considered consistent with the approach taken with respect to the performance requirements applicable to each category.

The issue of appropriate maneuvering load factors for maneuvering conditions (structural requirements) is of significance. The maneuvering load factors included are the 3.5 positive and 1.0 negative, which are the same as in Part 6. The values are unchanged due to lack of substantiation of other values; however, because certain comments questioned the necessity for such high values for transport rotorcraft, this is being made a matter for further study.

Interested persons have been afforded an opportunity to participate in the making of this part (20 F. R. 3114), and due consideration has been given to all relevant matter presented.

In consideration of the foregoing, the Civil Aeronautics Board hereby adopts Part 7 of the Civil Air Regulations (14 CFR Part 7) to read as follows, effective August 1, 1956:

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AUTHORITY: §§ 7.0 to 7.751 issued under sec. 205, 52 Stat. 984; 49 U. S. C. 425. Interpret or apply secs. 601, 603, 52 Stat. 1007, 1009, as amended; 49 U.S.C. 551, 553.

SUBPART A-GENERAL

APPLICABILITY AND DEFINITIONS

§ 7.0 *Applicability of this part* This part establishes standards with which compliance shall be demonstrated for the issuance of and changes to type certificates for Transport Category A and Transport Category B rotorcraft. This part, until superseded or rescinded, shall apply to all transport category rotorcraft for which applications for type certification in the transport categories are made after the effective date of this part (August 1, 1956).

§ 7.1 *Definitions.* As used in this part terms are defined as follows:

(a) *Administration*-(1) *Administrator.* The Administrator is the Administrator of Civil Aeronautics.

(2) *Applicant.* An applicant is a person or persons applying for approval of a rotorcraft or any part thereof.

(3) *Approved.* Approved, when used alone or as modifying terms such as means, devices, specifications, etc., means approved by the Administrator. (See § 7.18.)

(b) *Rotorcraft types*-(1) Rotorcraft. A rotorcraft is any aircraft deriving its principal lift from one or more rotors.

(2) *Helicopter.* A helicopter is a rotorcraft which depends principally for its support and motion in the air upon the lift generated by one or more power-driven rotors, rotating on substantially vertical axes.

(3) *Gyroplane.* A gyroplane is a rotorcraft which depends principally for its support upon the lift generated by one or more rotors which are not power driven, except for initial starting, and which are caused to rotate by the action of the air when the rotorcraft is in motion. The propulsion is independent of the rotor system and usually consists of conventional propellers.

(4) *Gyrodyne.* A gyrodyne is a rotorcraft which depends principally for its support upon the lift generated by one or more rotors, which are partially power driven, rotating on substantially vertical axes. The propulsion is independent of the rotor system and usually consists of conventional propellers.

(c) *General design*-(1) *Standard atmosphere.* The standard atmosphere is an atmosphere defined as follows:

(i) The air is a dry, perfect gas,

(ii) The temperature at sea level is 59°F.,

(iii) The pressure at sea level is 29.92 inches Hg,

(iv) The temperature gradient from sea level to the altitude at which the temperature equals -67° F is -0.003566° F./ft. and zero thereabove, and

(v) The density ρ_o at sea level under the above condition 0.002378 pound sec^2/ft^4.

(2) *Maximum anticipated air temperature.* The maximum anticipated air temperature is a temperature specifie the purpose of compliance with the powerplant cooling stanc (See §7.451.)

(3) *Aerodynamic coefficients.* Aerodynamic coefficient are nondimensional coefficients for forces and moments. The correspond with those adopted by the U. S. National Advisor Committee for Aeronautics.

(4) *Autorotation.* Autorotation is a rotorcraft flight condition in which the lifting rotor is driven entirely by the ac of the air when the rotorcraft is in motion.

(5) *Autorotative landing.* An autorotative landing is a landing of a rotorcraft in which the entire maneuver is accomp without the application of power to the rotor.

(6) *Autorotative landing distance.* Autorotative landir distance is the horizontal distance required to make an autorc landing and come to a complete stop (to a speed of approxima 3 mph for seaplanes or floatplanes) from a height of 50 feet al the landing surface.

(7) Ground resonance. Ground resonance is the mechanic instability encountered when the rotorcraft is in contact with ground.

(8) Mechanical instability. Mechanical instability is an unstable resonant condition due to the interaction between tl rotor blades and the rotorcraft structure, while the rotorcraft i the ground or airborne.

(d) *Weights*-(1) *Maximum weight.* The maximum weigh of the rotorcraft is that maximum at which compliance with the requirements of this part is demonstrated. (See § 7.101.)

(2) *Minimum weight.* The minimum weight of the rotorcraft is that minimum at which compliance

with the requirements of this part is demonstrated. (See § 7.101.)

(3) *Empty weight*. The empty weight of the rotorcraft is a readily reproducible weight which is used in the determination of the operating weights. (See § 7.104.)

(4) *Design maximum weight*. The design maximum weight is the maximum weight of the rotorcraft at which compliance is shown with the structural loading conditions. (See § 7.101.)

(5) *Design minimum weight*. The design minimum weight is the minimum weight of the rotorcraft at which compliance is shown with the structural loading conditions. (See § 7.101.)

(6) *Design unit weight*. The design unit weight is a representative weight used to show compliance with the structural design requirements.

(i) Gasoline 6 pounds per U. S. gallon.

(ii) Lubricating oil 7.5 pounds per U. S. gallon.

(iii) Crew and passengers 170 pounds per person.

(e) *Speeds*-(1) *IAS*. Indicated air speed is equal to the pitot static air-speed indicator reading as installed in the rotorcraft without correction for air-speed indicator system errors but including the sea level standard adiabatic compressible flow correction. (This latter correction is included in the calibration of the air-speed instrument dials.) (See §§ 7.612 and 7.732.)

(2) *CAS*. Calibrated air speed is equal to the air-speed indicator reading corrected for position and instrument error. (As a result of the sea level adiabatic compressible flow correction to the airspeed instrument dial, CAS is equal to the true air speed TAS in standard atmosphere at sea level.)

(3) *EAS*. Equivalent air speed is equal to the air-speed indicator reading corrected for position error, instrument error, and for adiabatic compressible flow for the particular altitude. (EAS is equal to CAS at sea level in standard atmosphere.)

(4) *TAS*. True air speed of the rotorcraft relative to undisturbed air, (TAS=EAS$(\rho_0/\rho)^{1/2}$)

(5) V_H. The maximum speed obtainable in level flight with rated rpm and power.

(6) V_{NE}. The never-exceed speed. (See § 7.711.)

(7) V_x. The speed for best angle of climb.

(8) V_y. The speed for best rate of climb.

(f) *Structural*-(1) *Limit load*. A limit load is the maximum load anticipated in normal conditions of operation. (See § 7.200.)

(2) *Ultimate load*. An ultimate load is a limit load multiplied by the appropriate factor of safety. (See § 7.200.)

(3) *Factor of safety*. The factor of safety is a design factor used to provide for the possibility of loads greater than those anticipated in normal conditions of operation and for uncertainties in design. (See § 7.200.)

(4) *Load factor*. The load factor is the ratio of a specified load to the total weight of the rotorcraft; the specified load may be expressed in terms of any of the following: aerodynamic forces, inertia forces, or ground or water reactions.

(5) *Limit load factor*. The limit load factor is the load factor corresponding with limit loads.

(6) *Ultimate load factor*. The ultimate load factor is the load factor corresponding with ultimate loads.

(7) *Fitting*. A fitting is a part or terminal used to join one structural member to another. (See § 7.307 (d).)

(g) *Power installation*[1] —(1) *Brake horsepower*. Brake horsepower is the power delivered at the propeller shaft of the engine.

(2) *Take-off power*. Take-off power is the brake horsepower developed under standard sea level conditions, under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for use in the normal takeoff, and limited in use to a maximum continuous period as indicated in the approved engine specification.

(3) *Maximum continuous power*. Maximum continuous power is the brake horsepower developed in standard atmosphere at a specified altitude under the maximum conditions of crankshaft rotational speed and engine manifold pressure approved for use during periods of unrestricted duration.

(4) *Manifold pressure*. Manifold pressure is the absolute pressure measured at the appropriate point in the induction system, usually in inches of mercury.

(5) *Critical altitude*. The critical altitude is the maximum altitude at which in standard atmosphere it is possible to maintain, at a specified rotational speed, a specified power or a specified manifold pressure. Unless otherwise slated, the critical altitude is the maximum altitude at which it is

[1]For engine airworthiness requirements see Part 13 of this subchapter.

possible to maintain, at the maximum continuous rotational speed, one of the following:

(i) The maximum continuous power, in the case of engines for which this power rating is the same at sea level and at the rated altitude.

(ii) The maximum continuous rated manifold pressure, in the case of engines the maximum continuous power of which is governed by a constant manifold pressure.

(h) *Propellers and rotors.*[2] — (1) *Rotor.* Rotor is a system of rotating airfoils.

(2) *Main rotor.* The main rotor is the main system of rotating airfoils providing sustentation for the rotorcraft.

(3) *Auxiliary rotor.* An auxiliary rotor is one which serves either to counteract the effect of the main rotor torque on the rotorcraft, or to maneuver the rotorcraft about one or more of its three principal axes.

(4) *Axis of no feathering.* The axis of no feathering is the axis about which there is no first harmonic feathering or cyclic pitch variation.[3]

(5) *Plane of rotor disc.* The plane of rotor disc is a reference plane at right angles to the axis of no feathering.

(6) *Tip speed ratio.* The tip speed ratio is the ratio of the rotorplane flight velocity component in the plane of rotor disc to the rotational tip speed of the rotor blades expressed as follows:

$$\mu = \frac{V \cos a}{\Omega R}$$

where:

V = air speed of the rotorcraft along flight path (fps).

a = angle between projection in plane of symmetry of axis of no feathering and a line perpendicular to the flight path (radians, positive when axis is pointing aft).

Ω = angular velocity of rotor (radius per second), and

R = rotor radius (ft.)

(i) *Fire protection* — (1) *Fireproof.* Fireproof material means a material which will withstand heat at least as well as steel in dimensions appropriate for the purpose for which it is to be used. When applied to material and parts used to confine fires in designated fire zones, fireproof means that the material or part will perform this function under the most severe conditions of fire and duration likely to occur in such zones.

(2) *Fire-resistant.* When applied to sheet or structural members, fire-resistant material means a material which will withstand heat at least as well as aluminum alloy in dimensions appropriate for the purpose for which it is to be used. When applied to fluid-carrying lines, other flammable fluid system components, wiring, air ducts, fittings, and powerplant controls, this term refers to a line and fitting assembly, component, wiring or duct, or controls which will perform the intended functions under the heat and other conditions likely to occur at the particular location.

(3) *Flame-resistant.* Flame-resistant material means material which will not support combustion to the point of propagating, beyond safe limits, a flame after the removal of t ignition source.

(4) *Flash-resistant.* Flash-resistant material means material which will not burn violently when ignited.

(5) *Flammable.* Flammable pertains to those fluids or gases which will ignite readily or explode.

(j) *Miscellaneous.* (1) *Protective breathing equipment.* Protective breathing equipment is equipment designed to prevent the breathing of noxious gases which mi present as contaminants in the air within the rotorcraft in emergency situations (see § 7.646).

CERTIFICATION

§ 7.10 *Eligibility for type certificates.* A rotorcraft shall b eligible for type certification under the provisions of this part complies with the airworthiness provisions hereinafter establ or if the Administrator finds that the provision or provisions complied with are compensated for by factors which provide equivalent level of safety: Provided, That the Administrator f no feature or characteristic of the rotorcraft which renders it u

§ 7.11 *Designation of applicable regulations.* The provisions of this section shall apply to all rotorcraft types certificated under this part irrespective of the date of applicat for type certificate.

(a) Unless otherwise established by the Board, the rotor shall comply with the provisions of this part together with all amendments thereto effective on the date of application for ty certificate, except that compliance with later effective amendm may be elected or required pursuant to paragraphs (c), (d), an of this section.

[2] For propeller airworthiness requirements see Part 14 of this subchapter.
[3] See NACA Technical Note No. 1604.

(b) If the interval between the date of application for type certificate and the issuance of the corresponding type certificate exceeds five years, a new application for type certificate shall be required. At the option of the applicant, a new application may be filed prior to the expiration of the five-year period. In either instance the applicable regulations shall be those effective on the date of the new application in accordance with paragraph (a) of this section.

(c) During the interval between filing the application and the issuance of a type certificate, the applicant may elect to show compliance with any amendment of this part which becomes effective during that interval, in which case all other amendments found by the Administrator to be directly related shall be complied with.

(d) Except as otherwise provided by the Board, or by the Administrator pursuant to §1.24 of this subchapter, a change to the type certificate (see §7.13 (b)) may be accomplished, at the option of the holder of the type certificate, either in accordance with the regulations incorporated by reference in the type certificate pursuant to §7.13 (c), or in accordance with subsequent amendments to such regulations in effect on the date of application for approval of the change, subject to the following provisions:

(1) When the applicant elects to show compliance with an amendment to the regulations in effect on the date of application for approval of a change, he shall show compliance with all amendments which the Administrator finds are directly related to the particular amendment selected by the applicant.

(2) When the change consists of a new design or a substantially complete redesign of a component, equipment installation, or system installation of the rotorcraft, and the Administrator finds that the regulations incorporated by reference in the type certificate pursuant to §7.13 (c) do not provide complete standards with respect to such change, he shall require compliance with such provisions of the regulations in effect on the date of application for approval of the change as he finds will provide a level of safety equal to that established by the regulations incorporated by reference at the time of issuance of the type certificate.

NOTE: Example of new or redesigned components and installations which might require compliance with regulations in effect on the date of application for approval, are: New powerplant installation which is likely to introduce additional fire or operational hazards unless additional protective measures are incorporated; the installation of a new rotor system or a new electric power system.

(e) If changes listed in subparagraphs (1) through (3) of this paragraph are made, the rotorcraft shall be considered as a new type, in which case a new application for type certificate shall be required and the regulations together with all amendments thereto effective on the date of the new application shall be made applicable in accordance with paragraphs (a), (b), (c), and (d) of this section.

(1) A change in the number of engines or rotors;

(2) A change to engines or rotors employing different principles of operation or propulsion;

(3) A change in design, configuration, power, or weight which the Administrator finds is so extensive as to require a substantially complete investigation of compliance with the regulations.

§7.12 *Recording of applicable regulations.* The Administrator, upon the issuance of a type certificate, shall record the applicable regulations with which compliance was demonstrated. Thereafter, the Administrator shall record the applicable regulations for each change in the type certificate which is accomplished in accordance with regulations other than those recorded at the time of issuance of the type certificate. (See §7.11)

§7.13 *Type certificate.* (a) An applicant shall be issued a type certificate when he demonstrates the eligibility of the rotorcraft by complying with the requirements of this part in addition to the applicable requirements in Part 1 of this subchapter.

(b) The type certificate shall be deemed to include the type design (see §7.14 (b)), the operating limitations for the rotorcraft (see §7.700), and any other conditions or limitations prescribed by the regulations in this subchapter.

(c) The applicable provisions of this part recorded by the Administrator in accordance with §7.12 shall be considered as incorporated in the type certificate as though set forth in full.

§7.14 *Data required.* (a) The applicant for a type certificate shall submit to the Administrator such descriptive data, test reports, and computations as are necessary to demonstrate that the rotorcraft complies with the requirements of this part.

(b) The descriptive data required in paragraph (a) of this section shall be known as the type design and shall consist of such drawings and specifications as are necessary to disclose the configuration of the rotorcraft and all the design features covered in the requirements of this part, such information on dimensions, materials, and processes as is necessary to define the structural strength of the rotorcraft, and such other data as are necessary to permit by comparison the determination of the airworthiness of subsequent rotorcraft of the same type.

§ 7.15 *Inspections and tests.* Inspections and tests shall include all those found necessary by the Administrator to insure that the rotorcraft complies with the applicable airworthiness requirements and conforms to the following:

(a) All materials and products are in accordance with the specifications in the type design.

(b) All parts of the rotorcraft are constructed in accordance with the drawings in the type design.

(c) All manufacturing processes, construction, and assembly are as specified in the type design.

§ 7.16 *Flight tests*. After proof of compliance with the structural requirements contained in this part, and upon completion of all necessary inspections and testing on the ground, and proof of the conformity of the rotorcraft with the type design, and upon receipt from the applicant of a report of flight tests performed by him, the following shall be conducted:

(a) Such official flight tests as the Administrator finds necessary to determine compliance with the requirements of this part.

(b) After the conclusion of flight tests specified in paragraph (a) of this section, such additional flight tests as the Administrator finds necessary to ascertain whether there is reasonable assurance that the rotorcraft, its components, and equipment are reliable and function properly. The extent of such additional flight tests shall depend upon the complexity of the rotorcraft, the number and nature of new design features, and the record of previous tests and experience for the particular rotorcraft type, its components, and equipment. If practicable, these flight tests shall be conducted on the same rotorcraft used in the flight tests specified in paragraph (a) of this section and in the rotor drive endurance tests specified in § 7.405.

§ 7.17 *Airworthiness, experimental, and production certificates*. (For requirements with regard to these certificates see part 1 of this subchapter.

§ 7.18 *Approval of materials, parts, processes, and appliances.* (a) Materials, parts, processes, and appliances shall be approved upon a basis and in a manner found necessary by the Administrator to implement the pertinent provisions of the regulations in this subchapter. The Administrator may adopt and publish such specifications as he finds necessary to administer this regulation, and shall incorporate therein such portions of the aviation industry, Federal, and military specifications respecting such materials, parts, processes, and appliances as he finds appropriate.

NOTE: The provisions of this paragraph are intended to a approval of materials, parts, processes, and appliances under system of Technical Standard Orders, or in conjunction with certification procedures for a rotorcraft, or by any other form approval by the Administrator.

(b) Any material, part, process, or appliance shall be dee to have met the requirements for approval when it meets the pertinent specifications adopted by the Administrator, and th manufacturer so certifies in a manner prescribed by the Administrator.

§ 7.19 *Changes in type design*. (For requirements with regard to changes in type design and the designation of appli regulations therefor, see § 7.11 (d) and (e), and Part 1 of this subchapter.)

ROTORCRAFT CATEGORIES

§ 7.20 *Rotorcraft categories.* (a) For the purpose of certification under this part, rotorcraft are divided upon the b their size and complexity into the following categories:

(1) *Transport category A; suffix A.* Rotorcraft in this category shall be multiengined.

(2) *Transport category B; suffix B.* Rotorcraft in this category are limited to 20,000 pounds or less, and can be sing multiengined.

(b) A multiengined rotorcraft may be certificated under requirements of a particular category, or in both categories, if the requirements of each category are met. Sections of this pa which apply to only one category are identified by the approp suffix added to the section number, as indicated in paragraph this section. All sections not identified by a suffix are applica both categories except as otherwise specified.

Subpart B -Flight

GENERAL

§ 7.100 *Proof of compliance*. (a) Compliance with the requirements prescribed in this subpart shall be established b flight or other tests conducted upon a rotorcraft of the type f which a certificate of airworthiness is sought or by calculatio based on such tests, provided that the results obtained by calculations are equivalent in accuracy to the results of direct testing.

(b) Compliance with each requirement shall be established at all appropriate combinations of rotorcraft weight and center of gravity position within the range of loading conditions for which certification is sought by systematic investigation of all these combinations, except where compliance can be inferred reasonable from those combinations which are investigated.

(c) The controllability, stability, and trim of the rotorcraft shall be established at all altitudes up to the maximum anticipated operating altitude.

(d) The applicant shall provide a person holding an appropriate pilot certificate to make the flight tests, but a designated representative of the Administrator shall pilot the rotorcraft when it is found necessary for the determination of compliance with the airworthiness requirements.

(e) Official type tests shall be discontinued until corrective measures have been taken by the applicant when either:

(1) The applicant's test pilot is unable or unwilling to conduct any of the required flight tests, or

(2) It is found that requirements which have not been met are so substantial as to render additional test data meaningless or are of such a nature as to make further testing unduly hazardous.

(f) Adequate provision shall be made for emergency egress and for the use of parachutes by members of the crew during the flight tests.

(g) The applicant shall submit to the authorized representative of the Administrator a report covering all computations and tests required in connection with calibration of instruments used for test purposes and correction of test results to standard atmospheric conditions. The authorized representative of the Administrator shall conduct any flight tests which he finds necessary to check the calibration and correction report.

§ 7.101 *Weight limitations*. The maximum and minimum weights at which the rotorcraft will be suitable for operation shall be established as follows:

(a) Maximum weights shall not exceed any of the following:

(1) The weight selected by the applicant;

(2) The design weight for which the structure has been proven; or

(3) The maximum weight at which compliance with all the applicable flight requirements has been demonstrated.

(b) It shall be acceptable to establish maximum weights for each altitude and for each practicably separable operating condition; e.g., take-off, en route, landing.

(c) Minimum weights shall not be less than any of the following:

(1) The minimum weight selected by the applicant;

(2) The design minimum weight for which the structure has been proven; or

(3) The minimum weight at which compliance with all of the applicable flight requirements has been demonstrated. (See § 7.741 (c).)

§ 7.102 Center of gravity limitations. (a) Center of gravity limits shall be established as the most forward position permissible for each weight established in accordance with § 7.101 and the most aft position permissible for each of such weights. Such limits of the center of gravity range shall not exceed any of the following:

(1) The extremes selected by the applicant,

(2) The extremes for which the structure has been proven,

(3) The extremes at which compliance with all of the applicable flight requirements has been demonstrated.

(b) Loading instructions shall be provided if the center of gravity position under any possible loading condition between the maximum and minimum weights as specified in § 7.101, with assumed weights for individual passengers and crew members variable over the anticipated range of such weights, lies beyond:

(1) The extremes selected by the applicant,

(2) The extremes for which the structure has been proven,

(3) The extremes for which compliance with all of the applicable flight requirements has been demonstrated. (See § 7.741 (c).)

7.103 *Rotor limitations and pitch settings*—(a) *Power-on.* A range of power-on operating speeds for the main rotor(s) shall be established which will provide adequate margin to accommodate the variation of rotor rpm attendant to all maneuvers appropriate to the rotorcraft type and consistent with the type of synchronizer or governor used, if any (see §§ 7.713 (b) (2) and 7.714 (b)). A means shall be provided to prevent rotational speeds substantially less than the approved minimum rotor rpm in any sustained flight condition with full throttle and with pitch control of the main rotor(s) in the high-pitch position. It shall be acceptable for such means to allow the use of higher pitch in an emergency, provided that the means incorporate provisions to prevent inadvertent transition from the normal operating range to the higher pitch angles.

(b) *Power-off.* A range of power-off operating rotor speeds shall be established which will permit execution of all autorotative flight maneuvers appropriate to the rotorcraft type throughout the range of air speeds and weights for which certification is sought (see §§ 7.713 (a) and 7.713 (b) (1)). A rotor blade low-pitch limiting device shall be positioned to provide sufficient rotational speed within the approved rotor speed range in any autorotative flight condition under the most adverse combinations of weight and air speed with the rotor pitch control in the full low-pitch position. However, it shall be possible to prevent overspeeding of the rotor without requiring exceptional piloting skill.

§ 7.104 *Empty weight.* (a) The empty weight, and the corresponding center of gravity position, shall be determined by weighing the rotorcraft. This weight shall exclude the weight of the crew and payload, but shall include the weight of all fixed ballast, unusable fuel supply (see § 7.416), undrainable oil, total quantity of engine coolant, and total quantity of hydraulic fluid.

(b) The condition of the rotorcraft at the time of weighing shall be one which can be easily repeated and easily defined, particularly as regards the contents of the fuel, oil, and coolant tanks, and the items of equipment installed. (See § 7.740.)

§ 7.105 *Use of ballast.* Removable ballast may be used to enable the rotorcraft to comply with the flight requirements. (See §§ 7.391, 7.738, and 7.740.)

PERFORMANCE

§ 7.110 *General.* (a) The performance prescribed in this subpart shall be determined using normal pilot skill and shall not require exceptionally favorable conditions. Compliance shall be shown for sea level standard conditions in still air and for the range of atmospheric variable as selected by the applicant. The performance as affected by engine power, instead of being based on dry air, shall be based on 80 percent relative humidity or 0.7" Hg. Vapor pressure whichever is less.

(b) Each set of performance data required for a particular flight condition shall be determined with the powerplant accessories absorbing the normal amount of power appropriate to that flight condition.

NOTE: The Administrator is authorized to establish appropriate margins to be applied to the performance data determined in accordance with this part for operating variables not covered in the performance determination; e.g., variations in pilot technique, engine power, rotor drag, rough air, etc.

§ 7.111 *Limiting height and speeds for safe landing following power failure*— (a) *Category A.* If a range of heights exists at any speed, including zero, within which it is possible to make a safe landing when the critical engine is su made inoperative with take-off power on the operating engine(s the range of heights and its variation with forward speed shal established (see §§ 7.715 and 7.741 (f)).

(b) *Category B.* If a range of heights exists at any spee including zero, within which it is not possible to make a safe landing following complete power failure, the range of height its variation with forward speed shall be established (see §§ 7.718 and 7.741(f)).

(c) *Category B; optional requirements for multiengined rotorcraft.* In lieu of compliance with paragrap (b) of this section, a multiengine rotorcraft that is certificated accordance with Transport Category A powerplant installation requirements as well as with § 7.384 (a) of this part, may, at the option of the applicant, comply with paragraph (a) of this sec

§ 7.112 *Take-off; general.* (a) Category A: The take-off performance shall be determined and scheduled in such a ma that, in the event of one engine becoming inoperative at any after the start of take-off, it shall be possible for the rotorcraft either to return to and stop safely on the take-off area, or to continue the take-off, climb-out, and attain a rotorcraft configuration and airspeed at which compliance with the climb requirement of § 7.115 (a) (2) is met.

(b) The take-off data required by §§ 7.113, 7.114, and 7.115 (a) (1) and (a) (2) shall be determined under the following conditions:

(1) At all weights, altitudes, and temperatures selected b the applicant, and

(2) With the operating engines not exceeding their appr limitations.

(c) All take-off data, when corrected, shall assume a leve take-off surface, and shall be determined on a smooth, dry, hard surface, and in such a manner that reproduction of the performance does not require either exceptional skill or alertness on the part of the pilot or exceptionally favorable conditions. (For wind and runway gradient corrections see appropriate operating rules of the regulations in this subchapter.)

§ 7.113 *Category A; critical decision point.* The critical decision point shall be any combination of height and speed as selected by the applicant in demonstrating the take-off as defined in § 7.114. The method used to attain the critical decision point shall be such as to avoid flight within the critical areas of the limiting height-speed envelope as established in accordance with § 7.111(a).

§ 7.114 *Take-off* (a) *Category A*. The take-off flight path and accelerated stop path shall be established. It shall be permissible to initiate the take-off in any manner provided the take-off surface is defined and adequate safeguards are maintained to assure proper center of gravity position and control position.

(1) The accelerated stop path shall be established with take-off power on all engines from the start of take-off to the critical decision point, at which point it shall be assumed that the critical engine becomes inoperative, and the rotorcraft is brought to a safe stop.

(2) The take-off climb-out path shall be established with take-off power on all engines from the start of take-off to the critical decision point, at which point it shall be assumed that the critical engine becomes inoperative. With the remaining engines operating within their approved limitations, the climb-out shall be accomplished at speeds not less than the take-off safety speed used in meeting the rate of climb specified in § 7.115 (a)(1), and in such a manner that the airspeed and configuration used in meeting the climb requirement specified in § 7.115 (a)(2) are attained.

(3) The take-off climb-out and accelerate-stop shall be accomplished in such a manner as to provide a safe and smooth transition between all stages of the maneuver.

(b) *Category B*. The take-off and climb-out shall be established with the most unfavorable center of gravity position. It shall be permissible to initiate the take-off in any manner provided the take-off surface is defined and adequate safeguards are maintained to assure proper center of gravity position and control position and provided a landing can be made safely at any point along the flight path in the case of an engine failure (see § 7.111 (b)).

§ 7.115 *Climb; one-engine-inoperative*— (a) *Category A*. The following take-off and en route climb requirements shall be met by all Category A rotorcraft:

(1) *Take-off climb; gear extended*. The steady rate of climb without ground effect shall not be less than 100 fpm for each weight, altitude, and temperature condition for which take-off data are to be scheduled with:

(i) The critical engine inoperative and the remaining engine(s) operating within their approved limitations.

(ii) Center of gravity in the most unfavorable position permitted for take-off,

(iii) Landing gear extended.

(iv) The take-off safety speed as selected by the applicant (see § 7.114 (a)(2)), and

(v) Cowl flaps or other means of controlling the engine-cooling air supply in the position which provides adequate cooling in the hot-day condition.

(2) *Climb at maximum continuous power*. The steady rate of climb without ground effect shall not be less than 150 fpm for each weight, altitude, and temperature condition for which take-off data are to be scheduled with:

(i) The critical engine inoperative and the remaining engine(s) operating at maximum continuous power,

(ii) Center of gravity in the most unfavorable position permitted for take-off,

(iii) Landing gear retracted, if retractable,

(iv) The speed as selected by the applicant, and

(v) Cowl flaps or other means of controlling the engine-cooling air supply in the position which provides adequate cooling in the hot-day condition.

(3) En route climb. The steady rate of climb in feet per minute at any altitude at which the rotorcraft is expected to operate, and at any weight within the range of weights to be specified in the airworthiness certificate, shall be determined with:

(i) The critical engine inoperative, and the remaining engine(s) operating at the maximum continuous power available at such altitude,

(ii) Center of gravity in the most unfavorable position,

(iii) The landing gear retracted, if retractable,

(iv) The speed as selected by the applicant, and

(v) Cowl flaps or other means of controlling the engine-cooling air supply in the position which provides adequate cooling in the hot-day condition.

(b) *Category B*. The following climb requirements shall be applicable to Category B rotorcraft:

(1) For all rotorcraft, the steady rate of climb at the best rate-of-climb speed with maximum continuous power on all engines and landing gear retracted, if retractable, shall be determined over the range of weights, altitudes, and temperatures for which certification is sought (see § 7.740). For all rotorcraft except helicopters this rate of climb shall provide a steady gradient of climb under standard sea level conditions of not less than 1:6.

(2) For multiengine helicopters complying with the optional requirement of § 7.111 (c), the steady rate of climb or descent shall be determined at the best rate-of-climb or rate-of-descent speed with one engine inoperative and the remaining engine(s) operating at a maximum continuous power.

(3) For all helicopters, the steady angle of glide shall be determined at the minimum rate-of-descent speed in autorotation at maximum weight.

§ 7.116 *Hovering or minimum operating performance*. (a) Category A: The hovering performance shall be determined over the range of weights, altitudes, and temperatures for which take-off data are scheduled with not more than take-off power on all engines, landing gear extended, and at a height above the ground consistent with the procedure used in the establishment of take-off and accelerate-stop distance.

(b) Category B: Hovering performance for helicopters shall be determined over the range of weights, altitudes, and temperatures for which certification is sought with take-off power on all engines, landing gear extended, and in the ground effect at a height above the ground consistent with normal take-off procedures. At maximum weight, under standard atmospheric conditions and under the aforementioned conditions, the hovering ceiling for helicopters shall not be less than 4,000 feet.

(c) For rotorcraft other than helicopters, the steady rate of climb at the minimum operating speed appropriate to the type with take-off power and landing gear extended shall be determined over the range of weights, altitudes, and temperatures for which certification is sought.

§ 7.117 *Landing; general*. (a) Category A: The landing performance shall be determined and scheduled in such a manner that, in the event of one engine becoming inoperative at any point in the approach path, it shall be possible for the rotorcraft to land and stop safely, and, further, it shall be possible from a point in the approach path to climb out and attain a rotorcraft configuration and air speed at which compliance with the climb requirement of § 7.115 (a) (2) is met.

(b) The landing data required by §7.118 shall be determined under the following conditions:

(1) At all weights, altitudes, and temperatures selected b[y] the applicant, and

(2) With the operating engines not exceeding their appr[oved] limitations.

(c) The approach and landing shall be made in such a m[anner] that its reproduction does not require an exceptional degree o[f] on the part of the pilot or exceptionally favorable conditions.

(d) During the landing there shall be no excessive vertical acceleration and no tendency to bounce, nose over, ground l[oop], porpoise, or water loop. All landing data, when corrected, sha[ll] assume a level landing surface, and shall be determined on a smooth, dry, hard surface. (For wind and runway gradient corrections see appropriate operating rules of the regulations [of this] subchapter.)

§ 7.118 *Landing*-(a) *Category A; one engine inoperative*. The approach, balked landing, and landing path[s] shall be established. The approach and landing speeds shall [be] selected by the applicant and be appropriate to the type of rotorcraft being certificated. Such paths shall be established [in the] following manner:

(1) The approach and landing path shall be established [so] as to avoid flight within the critical areas of the limiting height-speed envelope as established in accordance with § 7.11[?] (a) or, alternatively, at the option of the applicant, an envelope established in accordance with the landing condition with on[e] engine inoperative.

(2) The balked-landing path shall be established such th[at] from a height and speed combination in the approach path as selected by the applicant, a safe climb-out can be made and s[peeds] attained corresponding to the speeds required in meeting the [climb] requirements of § 7.115 (a) (1) and (a) (2).

(3) The maneuvers specified in subparagraphs (1) and ([2] of) this paragraph shall be accomplished in such a manner as to provide safe and smooth transition between each stage.

(b) *Category A; complete failure of all power*. It shall be possible to make a safe landing on a prepared runway following complete failure of all power during normal cruising operating conditions (see § 7.743 (a)(2)).

(c) *Category B; autorotative landing*. The horizontal distance required to land and come to a complete stop (to a speed of approximately 3 mph for seaplanes or float planes) from a point at a height of 50 feet above the landing surface shall be determined. In making this determination the following shall apply:

(1) The approach speed or speeds in the glide shall be appropriate to the type of rotorcraft and shall be chosen by the applicant.

(2) The approach and landing shall be made with power off and shall be entered from steady autorotation.

(3) The approach and landing path shall be such as to avoid flight within the critical areas of the limiting height-speed envelope as established in accordance with § 7.111 (b).

(d) *Category B-Optional requirements for multi-engined rotorcraft certificated in Transport Category B*. In lieu of compliance with the autorotative landing distance requirements specified in paragraph (c) of this section, a multi-engined rotorcraft that complies with the powerplant installation requirements for Category A and § 7.384 (a) may, at the option of the applicant, comply with paragraphs (a) and (b) of this section, omitting the climb-out requirement specified in paragraph (a)(2) of this section.

FLIGHT CHARACTERISTICS

§ 7.120 *General*. (a) The rotorcraft shall comply with the requirements prescribed in §§ 7.121 through 7.123 at all normally expected operating altitudes, under all critical loading conditions within the range of weight and center of gravity, and for all speeds, power, and rotor rpm conditions for which certification is sought.

(b) It shall be possible to maintain a flight condition and to make a smooth transition from one flight condition to another without requiring an exceptional degree of skill, alertness, or strength on the part of the pilot, and without danger of exceeding the limit load factor under all conditions of operation probable for the type, including those conditions normally encountered in the event of sudden powerplant failure.

(c) The eligibility of rotorcraft for night and instrument flight is contained in subparagraphs (1) and (2) of this paragraph.

(1) *Category A*. Rotorcraft in this category are eligible for night and instrument flight. To be eligible for night and instrument flight the rotorcraft shall be certificated in accordance with such additional flight characteristic rules as the Administrator finds are required for safe operations under these conditions.

(2) *Category B*. Rotorcraft in this category are not eligible for unlimited night and instrument flight. Rotorcraft in this category, however, are eligible for limited night flight, i.e., night flight under VFR conditions. To be eligible for limited night flight, compliance shall be shown with such requirements as the Administrator finds are necessary for safe operation under these conditions.

§ 7.121 *Controllability*. (a) The rotorcraft shall be safely controllable and maneuverable during steady flight and during the execution of any maneuver appropriate to the type of rotorcraft, including take-off, climb, level flight, turn, glide, and power-on or power-off landings.

(b) The margin of longitudinal and lateral cyclic control shall allow satisfactory pitching and rolling control at V_{NE} (see § 7.711), with:

(1) Maximum weight,

(2) Critical center of gravity,

(3) Power on and power off, and

(4) Critical rotor rpm.

(c) Compliance with paragraph (b) of this section shall include a demonstration with a power failure at V_H or V_{NE} whichever is less.

(d) There shall be established a wind velocity in which the rotorcraft can be operated without loss of control on or near the ground at the critical center of gravity and the critical rotor rpm in any maneuver appropriate to the type of rotorcraft; e.g., cross-wind take-offs, sideward or rearward flight. This wind velocity shall not be less than 20 mph.

§ 7.122 *Trim*. It shall be possible in steady level flight at any speed appropriate to the type of rotorcraft to trim the steady longitudinal and lateral control forces to zero. The trim device shall not introduce any undesirable discontinuities in the force gradients.

§ 7.123 *Stability*—(a) *General*. It shall be possible to fly the rotorcraft in normal maneuvers, including a minimum of three take-offs and landings, for a continuous period of time appropriate to the operational use of the particular type of rotorcraft without the pilot experiencing undue fatigue or strain. In addition, the rotorcraft shall comply with the requirements of paragraph (b) of this section.

(b) *Static longitudinal stability*. In the following configurations the characteristics of the longitudinal cyclic control shall be such that, with constant throttle and collective pitch settings, a rearward displacement of longitudinal control shall be necessary to obtain and maintain speeds below the specified trim speed, and a forward displacement shall be necessary to obtain and maintain speeds above the specified trim speed for the ranges of altitude and rotor rpm for which certification is sought:

(1) *Climb*. The stick position curve shall have a stable slope over a speed range from 15 percent of V_y or 15 mph, whichever is greater, below V_y to 20 percent of V_y or 15 mph, whichever is greater above V_y but in no case greater than 1.1 V_{NE} with:

(i) Critical weight and center of gravity,

(ii) Maximum continuous power,

(iii) Landing gear retracted, and

(iv) Trim at best rate-of-climb speed (V_y).

(2) *Cruise*. The stick position curve shall have a stable slope over a speed range from 0.7 V_H or 0.7 V_{NE}, whichever is less to 1.1 V_H or 1.1V_{NE}, whichever is less, with:

(i) Critical weight and center of gravity,

(ii) Power for level flight at 0.9 V_H or 0.9 V_{NE}, whichever is less.

(iii) Landing gear retracted, and

(iv) Trimmed at 0.9 V_H, or 0.9 V_{NE}, whichever is less.

(3) *Autorotation*. The stick position curve shall have a stable slope throughout the speed range for which certification is sought, with:

(i) Critical weight and center of gravity,

(ii) Power off,

(iii) Landing gear both retracted, if retractable, and extended, and

(iv) Trim at the speed for minimum rate of descent.

(4) *Hovering*. In the case of helicopters the stick position curve shall have a stable slope between the maximum approved rearward speed and a forward speed of 20 mph, with:

(i) Critical weight and center of gravity,

(ii) Power required for hovering in still air,

(iii) Landing gear retracted, and

(iv) Trim for hovering.

GROUND AND WATER HANDLING CHARACTERISTICS

§ 7.130 *General*. The rotorcraft shall be demonstrated to have satisfactory ground and water handling characteristics. There shall be no uncontrollable tendencies in any operating condit reasonably expected for the type.

§ 7.131 *Ground resonance*. There shall be no uncontrolla tendency for the rotorcraft to oscillate when the rotor is turni and the rotorcraft is on the ground.

§ 7.132 *Spray characteristics*. For rotorcraft equipped wi floats, the spray characteristics during taxiing, take-off, and landin shall be such as not to obscure the vision of the pilot nor pro damage to the rotors, propellers, or other parts of the rotorcra

MISCELLANEOUS FLIGHT REQUIREMENTS

§ 7.140 *Flutter and vibration*. All parts of the rotorcraft shall be demonstrated to be free from flutter and excessive vi under all speed and power conditions appropriate to the oper of the type of rotorcraft. (See also §§ 7.203 and 7.711.)

SUBPART C - STRUCTURE

GENERAL

§ 7.200 *Loads*. (a) Strength requirements of this subpart a specified in terms of limit and ultimate loads. Unless otherwis stated, the specified loads shall be considered as limit loads. determining compliance with these requirements the provisio forth in paragraphs (b) through (e) of this section shall apply

(b) The factor of safety shall be 1.5 unless otherwise specified, and shall apply to the external and inertia loads, un its application to the resulting internal stresses is more conservative.

(c) Unless otherwise provided, the specified air, ground water loads shall be placed in equilibrium with inertia forces, considering all items of mass in the rotorcraft.

(d) All loads shall be distributed in a manner closely approximating or conservatively representing actual conditio

(e) If deflections under load significantly change the distribution of external or internal loads, the redistribution sha taken into account.

§ 7.201 *Strength and deformation*. (a) The structure shal be capable of supporting limit loads without suffering detrimental permanent deformations.

(b) At all loads up to limit loads the deformation shall not be such as to interfere with safe operation of the rotorcraft.

(c) The structure shall be capable of supporting ultimate loads without failure. It shall support the load during a static test for at least 3 seconds, unless proof of strength is demonstrated by dynamic tests simulating actual conditions of load application.

§ 7.202 *Proof of structure*. (a) Proof of compliance of the structure with the strength and deformation requirements of § 7.201 shall be made for all critical loading conditions.

(b) Proof of compliance by means of structural analysis shall be acceptable only when the structure conforms to types for which experience has shown such methods to be reliable. In all other cases substantiating tests shall be required.

(c) In all cases certain portions of the structure shall be tested as specified in § 7.203.

§ 7.203 *Structural and dynamic tests*. At least the following structural tests shall be conducted to show compliance with the strength criteria:

(a) Dynamic and endurance tests of rotors and rotor drives, including controls (see § 7.405).

(b) Control surface and system limit load tests (see § 7.323).

(c) Control system operation tests (see § 7.324).

(d) Flight stress measurements (see §§ 7.221, 7.250, and 7.251).

(e) Landing gear shock absorption tests (see § 7.332).

(f) Ground vibration tests to determine the natural frequencies of the blades and major structural components of the rotorcraft.

(g) Such additional tests as may be found necessary by the Administrator to substantiate new and unusual features of the design.

§ 7.204 *Design limitations*. The following values shall be established by the applicant for purposes of showing compliance with the structural requirements specified in this subpart:

(a) Maximum and minimum design weights,

(b) Power-on and power-off main rotor rpm ranges (see §§ 7.103 and 7.713 through 7.741(b)).

(c) Maximum forward speeds for the power-on and power-off main rotor rpm ranges established in accordance with paragraph (b) of this section (see § 7.713).

(d) Maximum rearward and sideward flight speeds,

(e) Extreme positions of rotorcraft center of gravity to be used in conjunction with the limitations of paragraphs (b), (c), and (d) of this section.

(f) Rotational speed ratios between the powerplant and all connected rotating components, and

(g) Positive and negative limit maneuvering load factors.

FLIGHT LOADS

§ 7.210 *General*. Flight load requirements shall be complied with at all weights from the design minimum weight to the design maximum weight, with any practicable distribution of disposable load within prescribed operating limitations stated in the Rotorcraft Flight Manual (see § 7.741).

§ 7.211 *Flight load factor.* The flight load factor shall be assumed to act normal to the longitudinal axis of the rotorcraft, and shall be equal in magnitude and shall be opposite in direction to the rotorcraft inertia load factor at the center of gravity.

§ 7.212 *Maneuvering conditions*. The rotorcraft structure shall be designed for a positive maneuvering limit load factor of 3.5 and a negative maneuvering limit load factor of 1.0, except that lesser values shall be allowed if the applicant shows by analytical study and flight demonstrations that the probability of exceeding the values selected is extremely remote. Where such lesser values of maneuvering load factor are selected, the values selected shall be appropriate to each design weight condition between design minimum and design maximum values. In no case shall the limit load factors be less than 2.0 positive and 0.5 negative. Air loads shall be assumed to be applied at the center(s) of the rotor hub(s) and at any auxiliary lifting surface(s) and to act in such directions with distributions of load among the rotor(s) and auxiliary lifting surface(s) as necessary to represent all critical maneuvering motions of the rotorcraft applicable to the particular type, including flight at the maximum design rotor tip speed ratio under power-on and power-off conditions.

§ 7.213 *Gust conditions*. The rotorcraft structure shall be designed to withstand the loading due to vertical and horizontal gusts of 30 fps in velocity in conjunction with the critical rotorcraft air speeds, including hovering.

§ 7.214 *Yawing conditions.* The rotorcraft shall be designed for loads resulting from conditions specified in this section. Unbalanced aerodynamic moments about the center of gravity shall be reacted in a rational or a conservative manner considering the principal masses furnishing the reacting inertia forces. With the maximum main rotor speed and at a forward speed up to V_{NE} or V_H, whichever is less, the following maneuvers shall be considered:

(a) With the rotorcraft in unaccelerated flight at zero yaw, it shall be assumed that the cockpit directional control is suddenly displaced to the maximum deflection as limited by the control stop or by maximum pilot effort.

(b) With the directional control deflected as in paragraph (a) of this section, it shall be assumed that the rotorcraft yaws to a resulting sideslip angle.

(c) With the rotorcraft yawed to the static sideslip angle corresponding with the directional control deflection specified in paragraph (a) of this section, it shall be assumed that the directional control is suddenly returned to neutral.

CONTROL SURFACE AND SYSTEM LOADS

§ 7.220 *General.* The structure of all auxiliary rotors (antitorque and control), fixed or movable stabilizing and control surfaces, and all systems operating any flight controls shall be designed to comply with the provisions of §§ 7.221 through 7.226.

§ 7.221 *Auxiliary rotor assemblies.* Auxiliary rotor assemblies shall be tested in accordance with the provisions of § 7.405 for rotor drives. In addition, auxiliary rotor assemblies with detachable blades shall be substantiated for centrifugal loads resulting from the maximum design rotor rpm. In the case of auxiliary rotors with highly stressed metal components, the vibration stresses shall be determined in flight, and it shall be demonstrated that these stresses do not exceed safe values for continuous operation.

§ 7.222 *Auxiliary rotor attachment structure.* The attachment structure for the auxiliary rotors shall be designed to withstand a limit load equal to the maximum loads in the structure occurring under the flight and landing conditions.

§ 7.223 *Tail rotor guard.* When a tail rotor is provided on a rotorcraft, it shall not be possible for the tail rotor to contact the landing medium during a normal landing. If a tail rotor guard is provided which will contact the landing medium during landings and thus prevent tail rotor contact, suitable design loads for the guard shall be established, and the guard and its supporting structure shall be designed to withstand the established loads.

§ 7.224 *Stabilizing and control surfaces.* Stabilizing and control surfaces shall be designed to withstand the critical loading from maneuvers or from combined maneuver and gust. In no case shall the limit load be less than 15 pounds per square foot or a load due to C_N =0.55 at the maximum design speed. The load distribution shall simulate closely the actual pressure distribution conditions.

§ 7.225 *Primary control systems; general.* Longitudinal, lateral, vertical (collective pitch), and directional control syste shall be designed to the minimum requirements set forth in paragraphs (a) and (b) of this section.

(a) Manually operated control systems; including their supporting structure, shall be designed to withstand the load resulting from the limit pilot-applied forces as set forth in subparagraphs (1) through (3) of this paragraph, or the maxim loads which can be obtained in normal operation of the rotorc including any single power boost system failure (see § 7.328), whichever is greater. Where it can be shown that the system or the normal operating loads are such that a portion of the sy cannot react the specified pilot-applied forces of subparagraphs through (3) of this paragraph, that portion of the system shall designed to withstand the maximum loads which can be obtai normal operation of the rotorcraft, except that design loads le than those resulting from 0.60 of the specified pilot-applied forces shall not be employed.

(1) Foot-type controls - 130 pounds.

(2) Stick-type controls - 100 pounds fore and aft - 67 pounds laterally.

(3) Wheel-type controls - 100 pounds fore and aft - 53*D* inch-pounds couple at the rim of the control wheel (where *D* is wheel diameter, inches).

(b) The reaction to the applied loads shall be provided a follows:

(1) By the control stops only,

(2) By the control locks only,

(3) By the irreversible mechanism only (with the irrevers mechanism locked and with the control surface in all critical positions for the affected portions of the system within its lim motion),

(4) By the attachment of the control system to the rotor blade pitch control horn only (with the

control in all critical positions for the affected portions of the system within the limits of its motion), and

(5) By the attachment of the control system to the control surface horn (with the control in all critical positions for the affected portions of the system within the limits of its motion).

§ 7.226 *Dual primary flight control systems*. (a) When dual controls are provided, the system shall be designed for the pilots operating in opposition, using individual pilot loads equal to 75 percent of those obtained in accordance with § 7.225.

(b) The control system shall be designed for the pilots acting in conjunction using individual pilot loads equal to 75 percent of those obtained in accordance with § 7.225.

LANDING LOADS

§ 7.230 *General* - (a) *Loads and equilibrium*. The limit loads obtained in the landing conditions shall be considered as external loads which would occur in a rotorcraft structure if it were acting as a rigid body. In each of the conditions the external loads shall be placed in equilibrium with the linear and angular inertia loads in a rational or conservative manner. In applying the specified conditions the provisions of paragraphs (b) through (e) of this section shall be complied with.

(b) *Center of gravity positions*. The critical center of gravity positions within the certification limits shall be selected so that the maximum design loads in each of the landing gear elements are obtained.

(c) *Design weight*. The design weight used in the landing conditions shall not be less than the maximum weight of the rotorcraft. It shall be acceptable to assume a rotor lift, equal to two-thirds the design maximum weight, to exist throughout the landing impact and to act through the center of gravity of the rotorcraft. Higher values of rotor lift shall be acceptable if substantiated by tests and/or data which are applicable to the particular rotorcraft.

(d) *Load factor*. The structure shall be designed for a limit load factor selected by the applicant, of not less than the value of the limit inertia load factor substantiated in accordance with the provisions of § 7.332, except in conditions in which other values of load factors are prescribed.

(e) *Landing gear position*. The tires shall be assumed to be in their static position, and the shock absorbers shall be assumed to be in the most critical position, unless otherwise prescribed.

(f) *Landing gear arrangement*. The provisions of §§ 7.231 through 7.236 shall be applicable to landing gear arrangements where two wheels are located aft and one or more wheels are located forward of the center of gravity.

§ 7.231 *Level landing conditions*. (a) Under loading conditions prescribed in paragraphs (b) and (c) of this section, the rotorcraft shall be assumed to be in the following two level landing attitudes:

(1) All wheels contacting the ground simultaneously, and

(2) The aft wheels contacting the ground with the forward wheel(s) being just clear of the ground.

(b) The following two level landing loading conditions shall be considered. Where the forward portion of the landing gear has two wheels, the total load applied to the forward wheels shall be divided between the two wheels in a 40:60 proportion.

(1) Vertical loads shall be applied in accordance with the provisions of § 7.230.

(2) The vertical loads specified in subparagraph (1) of this paragraph shall be combined with a drag load at each wheel. The drag loads shall not be less than 25 percent of the respective vertical loads. For the attitude prescribed in paragraph (a) (1) of this section the resulting pitching moment shall be assumed resisted by the forward gear, while for the attitude prescribed in paragraph (a) (2) of this section the resulting pitching moment shall be assumed resisted by angular inertia forces.

(c) Drag components simulating the forces required to accelerate the wheel rolling assembly up to the specified ground speed shall be combined with the vertical reactions existing at the instant of peak drag loads. The ground speed for determination of the spin-up loads shall be assumed equal to 75 percent of the optimum forward flight speed for minimum rate of descent in autorotative flight. The vertical loads under this loading condition shall be in accordance with the provisions of § 7.230 (d). It shall be acceptable to apply this condition only to the landing gear and the attaching structure.

§ 7.232 *Nose-up landing condition*. The rotorcraft shall be assumed in the maximum nose-up attitude permitting clearance of the ground by all parts of the rotorcraft. The ground loads shall be applied perpendicularly to the ground.

§ 7.233 *One-wheel landing condition*. The rotorcraft shall be assumed in the level attitude to contact the ground on one of the wheels located aft of the center of gravity. The vertical load shall be the same as that obtained on the one side in the condition specified in § 7.231 (b)(1). The unbalanced external loads shall be reacted by the inertia of the rotorcraft.

§ 7.234 *Lateral-drift landing condition.* (a) The rotorcraft shall be assumed in the level landing attitude. Side loads shall be combined with one-half the maximum ground reactions obtained in the level landing conditions of § 7.231 (b)(1). These loads shall be applied at the ground contact point, unless the landing gear is of the full-swiveling type in which case the loads shall be applied at the center of the axle. The conditions set forth in paragraphs (b) and (c) of this section shall be considered.

(b) Only the wheels aft of the center of gravity shall be assumed to contact the ground. Side loads equal to 0.8 of the vertical reaction acting inward (on one side) and 0.6 of the vertical reaction acting outward (on the other side) shall be combined with the vertical loads specified in paragraph (a) of this section.

(c) The forward and aft wheels shall be assumed to contact the ground simultaneously. Side loads on the wheels aft of the center of gravity shall be applied in accordance with paragraph (b) of this section. A side load at the forward gear equal to 0.8 of the vertical reaction shall be combined with the vertical load specified in paragraph (a) of this section.

§ 7.235 *Brake roll conditions.* The rotorcraft attitudes shall be assumed to be the same as those prescribed for the level landing conditions in § 7.231 (a), with the shock absorbers deflected to their static position. The limit vertical load shall be based upon a load factor of 1.33. A drag load equal to the vertical load multiplied by a coefficient of friction of 0.8 shall be applied at the ground contact point of each wheel equipped with brakes, except that the drag load need not exceed the maximum value based on limiting brake torque.

§ 7.236 *Taxiing condition.* The rotorcraft and its landing gear shall be designed for loads which occur when the rotorcraft is taxied over the roughest ground which it is reasonable to expect in normal operation.

§ 7.240 *Ski landing conditions.* The structure of a rotorcraft equipped with skis shall be designed in compliance with the loading conditions set forth in paragraphs (a) through (c) of this section:

(a) *Up load conditions.* (1) A vertical load of *Pn* and a horizontal load of *Pn*/4 shall be applied simultaneously at the pedestal bearings, *P* being the maximum static weight on each ski when the rotorcraft is loaded to the maximum design weight. The limit load factor *n* shall be determined in accordance with § 7.230 (d).

(2) A vertical load equal to 1.33 *P* shall be applied at the pedestal bearings. (For *P* see subparagraph (1) of this paragraph.)

(b) *Side-load condition.* A side load of 0.35 *Pn* shall be applied in a horizontal plane perpendicular to the center line of the rotorcraft at the pedestal bearing. (For *P* and *n* see paragraph (a)(1) of this section.)

(c) *Torque-load condition.* A torque load equal to 1.33 *P* (ft.-lb.) shall be applied to the ski about the vertical axis throu the center line of the pedestal bearings. (For *P* see paragraph (a)(1) of this section.)

§ 7.245 *Float landing conditions.* The structure of a rotorcraft equipped with floats shall be designed in complianc with the loading conditions set forth in paragraphs (a) and (b) of this section:

(a) *Up load conditions.* (1) With the rotorcraft assume in the static level attitude a load shall be applied so that the resultant water reaction passes vertically through the center o gravity of the rotorcraft. The limit load factor shall be determ in accordance with § 7.230 (d) or shall be assumed to be the sam as the load factor determined for the ground type landing gea

(2) The vertical load prescribed in subparagraph (1) of t paragraph shall be applied together with an aft component eq 0.25 the vertical component.

(b) *Side load condition.* The vertical load in this condition equal to 0.75 the vertical load prescribed in paragraph (a)(1) of this section, divided equally between the floats, shall be applied together with a side component. The side component shall be equal to 0.25 the total vertical load in condition and shall be applied to one float only.

MAIN COMPONENT REQUIREMENTS

§ 7.250 *Main rotor structure.* The requirements of paragraphs (a) through (g) of this section shall apply to the main rotor assemblies including hubs and blades.

(a) The hubs, blades, blade attachments, and blade cont which are subject to alternating stresses shall be designed to withstand the repeated loading conditions likely to occur witl established service life for such parts. The stresses of critica shall be determined in flight in all attitudes appropriate to the of rotorcraft throughout the ranges of limitations prescribed i e service life of such parts shall be established by the applicant on the basis of fatigue tests or other methods found acceptable to the Administrator.

(b) The main rotor structure shall be designed to withstand the critical flight loads prescribed in §§ 7.210 through 7.214

(c) The main rotor structure shall be designed to withstand the limit loads prescribed in §§ 7.210 through 7.214 under conditions of autorotation necessary for normal operation.

(d) The rotor blades, hubs, and flapping hinges shall be designed to withstand a loading condition simulating the force of the blade impact against its stop during operation on the ground.

(e) The rotor assembly shall be designed to withstand loadings simulating other critical conditions which might be encountered in normal operation.

(f) The rotor assembly shall be designed to withstand, at all rotational speeds, including zero, the maximum torque likely to be transmitted thereto by the rotor drive in both directions. If a torque limiting device is provided in the transmission system, the design limit torque need not be greater than the torque defined by the limiting device, except that in no case shall the design limit torque be less than the limit torque specified in § 7.251 (c). The design torque shall be distributed to the rotor blades in a rational manner.

(g) The rotor assembly shall be designed to withstand the maximum torque likely to be transmitted thereto from sudden applications of the rotor brake if provided. The design torque shall be equally distributed among the rotor blades.

§ 7.251 *Fuselage and rotor pylon structure*. The requirements of paragraphs (a) through (e) of this section shall apply to the fuselage and rotor pylon structure.

(a) The structure shall be designed to withstand the critical loads prescribed in §§ 7.210 through 7.214. The balancing air loads and inertia loads occurring under the accelerated flight conditions as well as the thrust from auxiliary rotors and the torque reaction of the rotor drive systems shall be considered.

(b) The structure shall be designed to withstand the applicable ground loads prescribed in §§ 7.230 through 7.245.

(c) The engine mount and adjacent fuselage structure shall be designed to withstand loads occurring in the rotorcraft under the accelerated flight and landing conditions, including the effects of engine torque loads. In the case of engines having 5 or more cylinders, the limit torque shall be obtained by multiplying the mean torque as defined by the power conditions in § 7.1 (g)(3) by a factor of 1.33. For 4-, 3-, and 2-cylinder engines, the factors shall be 2, 3, and 4, respectively. When a gas turbine powerplant is used, the limit torque shall be obtained by multiplying the mean torque for maximum continuous power by a factor of 1.25.

(d) The structure shall be designed to withstand the loads prescribed in § 7.250 (d) and (g).

(e) Those parts of the basic structure which are directly subjected to alternating stresses and the sudden failure of which would threaten the structural integrity of the rotorcraft shall be designed to withstand the repeated loading conditions likely to occur within the established service life for such parts. The stresses of critical parts shall be determined in flight in all attitudes appropriate to the type of rotorcraft throughout the ranges of limitations prescribed in § 7.204. The service life of such parts shall be established by the applicant on the basis of fatigue tests or other methods found acceptable to the Administrator.

§ 7.252 *Auxiliary lifting surfaces*. The requirements of paragraphs (a) through (c) of this section shall apply to the auxiliary lifting surfaces.

(a) The structure shall be designed to withstand the critical flight loads prescribed in §§ 7.210 through 7.214.

(b) The structure shall be designed to withstand the applicable ground loads of §§ 7.230 through 7.245.

(c) The structure shall be designed to withstand loadings simulating other critical conditions which might be encountered in normal operations.

EMERGENCY LANDING CONDITIONS

§ 7.260 *General*. The requirements of paragraphs (a) through (c) of this section deal with emergency conditions of landing on land or water in which the safety of the occupants is considered, although it is accepted that parts of the rotorcraft may be damaged.

(a) The structure shall be designed to give every reasonable probability that all of the occupants, if they make proper use of the seats, belts, and other provisions made in the design (see § 7.355), will escape serious injury in the event of a minor crash landing (with wheels up if the rotorcraft is equipped with retractable landing gear) in which the occupants experience the following ultimate inertia forces relative to the surrounding structure:

(1) Upward 1.5g (downward 4.0g).

(2) Forward 4.0g.

(3) Sideward 2.0g.

(b) The use of a lesser value of the downward inertia force specified in paragraph (a) of this section shall be acceptable if it is shown that the rotorcraft structure can absorb the landing loads corresponding with the design maximum weight and an ultimate descent velocity of 5 fps without exceeding the value chosen.

(c) The inertia forces specified in paragraph (a) of this section shall be applied to all items of mass which would be apt to injure the passengers or crew if such items became loose in the event of a minor crash landing, and the supporting structure shall be designed to restrain these items.

§ 7.261 *Fuel tank protection*. When fuel tanks are located within the fuselage and below the passenger floor level in an area where there is a likelihood of tank rupture from ground impact in the emergency landing condition (see § 7.260), the fuselage structure in the area of such fuel tanks shall be designed to resist the crash impact and protect the fuel tanks from rupture.

NOTE: Fuselage keels whose design and structural strength are such as to resist crash impacts associated with the emergency landing conditions of § 7.260 without extreme distortion which might tend to rupture the fuel tank may be considered to comply with the requirements of this section.

SUBPART D -DESIGN AND CONSTRUCTION

GENERAL

§ 7.300 *Scope*. The rotorcraft shall not incorporate design features or details which experience has shown to be hazardous or unreliable. The suitability of all questionable design details or parts shall be established by tests.

§ 7.301 *Materials*. The suitability and durability of all materials used in the rotorcraft structure shall be established on the basis of experience or tests and shall conform to approved specifications which will insure their having the strength and other properties assumed in the design data.

§ 7.302 *Fabrication methods*. The methods of fabrication employed in constructing the rotorcraft structure shall be such as to produce a consistently sound structure. When a fabrication process such as gluing, spot welding, or heat treating requires close control to attain this objective, the process shall be performed in accordance with the approved process specification.

§ 7.303 *Standard fastenings*. All bolts, pins, screws, and rivets used in the structure shall be of an approved type. The use of an approved locking device or method is required for all such bolts, pins, and screws. Self-locking nuts shall not be used on bolts which are subject to rotation in operation.

§ 7.304 *Protection*. (a) All members of the structure shall suitably protected against deterioration or loss of strength in service due to weathering, corrosion, abrasion, or other caus

(b) Provision for ventilation and drainage of all parts of the structure shall be made where necessary for protection.

(c) In rotorcraft equipped with floats, special precautior shall be taken against corrosion from salt water, particularly w parts made from different metals are in close proximity.

§ 7.305 *Inspection provisions*. Means shall be provided t permit the close examination of those parts of the rotorcraft w require periodic inspection, adjustment for proper alignment a functioning, and lubrication of moving parts.

§ 7.306 *Material strength properties and design values*. (a) Material strength properties shall be based on a sufficient number of tests of material conforming to specifica to establish design values on a statistical basis.

(b) The design values shall be so chosen that the proba of any structure being understrength because of material vari is extremely remote.

(c) ANC-5, ANC-18, and ANC-23, Part II, values shall b used unless shown to be inapplicable in a particular case.

NOTE: ANC-5, "Strength of Metal Aircraft Elements," ANC-18, "Design of Wood Aircraft Structures," and ANC-23, "Sandwich Construction for Aircraft," are published by the Subcommittee on Air Force-Navy-Civil Aircraft Design Criteria, and may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

(d) The strength, detail design, and fabrication of the structure shall be such as to minimize the probability of disas fatigue failure.

NOTE: Points of stress concentration are one of the main sources of fatigue failure.

§ 7.307 *Special factors*-(a) *General*. Where there is uncertainty concerning the actual strength of a particular par structure, or where the strength is likely to deteriorate in service prior to normal replacement of the part, or where the strength is subject to appreciable variability due to uncertainties in manufacturing processes and inspection methods, the factor of safety prescribed in § 7.200 (b) shall be multiplied by a special factor of a value such as to make the probability of the part being understrength from these causes extremely remote. The special factors set forth in paragraphs (b) through (d) of this section shall be acceptable for this purpose.

(b) *Casting factors*. (1) Where only visual inspection of a casting is to be employed, the casting factor shall be 2.0 except that it need not exceed 1.25 with respect to bearing stresses.

(2) It shall be acceptable to reduce the factor of 2.0 specified in subparagraph (1) of this paragraph to a value of 1.25 if such a reduction is substantiated by testing at least three sample castings and if the sample castings as well as all production castings are visually and radiographically inspected in accordance with an approved inspection specification. During these tests the samples shall withstand the ultimate load multiplied by the factor of 1.25 and in addition shall comply with the corresponding limit load multiplied by a factor of 1.15.

(3) Casting factors other than those contained in subparagraphs (1) and (2) of this paragraph shall be acceptable if they are found to be appropriately related to tests and to inspection procedures.

(4) A casting factor need not be employed with respect to the bearing surface of a part if the bearing factor used (see paragraph (c) of this section) is of greater magnitude than the casting factor.

(c) *Bearing factors*. (1) Bearing factors of sufficient magnitude shall be used to provide for the effects of normal relative motion between parts and in joints with clearance (free fit) which are subject to pounding or vibration.

(2) A bearing factor need not be employed on a part if another special factor prescribed in this section is of greater magnitude than the bearing factor.

(d) *Fitting factors*. (1) A fitting factor of at least 1.15 shall be used on all fittings the strength of which is not proven by limit and ultimate load tests in which the actual stress conditions are simulated in the fitting and the surrounding structure. This factor shall apply to all portions of the fitting, the means of attachment, and the bearing on the members joined.

(2) In the case of integral fittings the part shall be treated as a fitting up to the point where the section properties become typical of the member.

(3) The fitting factor need not be employed where a type of joint made in accordance with approved practices is based on comprehensive test data; e.g., continuous joints in metal plating, welded joints, and scarf joints in wood.

(4) A fitting factor need not be employed with respect to the bearing surface of a part if the bearing factor used (see paragraph (c) of this section) is of greater magnitude than the fitting factor.

MAIN ROTOR

§ 7.310 *Main rotor blades; pressure venting and drainage*. Internal pressure venting of the main rotor blades shall be provided. Drain holes shall be provided and, in addition, the blades shall be designed to preclude the possibility of water becoming trapped in any section of the blade.

§ 7.311 *Stops*. The rotor blades shall be provided with stops, as required for the particular design, to limit the travel of the blades about their various hinges. Provision shall be made to keep the blades from hitting the droop stops except during the starting and stopping of the rotor.

§ 7.312 *Rotor and blade balance*. Rotors and blades shall be mass balanced to the degree necessary to prevent excessive vibrations and to safeguard against flutter at all speeds up to the maximum forward speed.

§ 7.313 *Rotor blade clearance*. Clearance shall be provided between the main rotor and all other parts of the rotorcraft to prevent the blades from striking any part of the rotorcraft during any operating condition.

CONTROL SYSTEMS

§ 7.320 *General*. All controls and control systems shall operate with ease, smoothness, and positiveness appropriate to their function. (See also §§ 7.350 and 7.353.)

§ 7.321 *Control system stops*. (a) All control systems shall be provided with stops which positively limit the range of motion of the pilot's controls.

(b) Control system stops shall be so located in the system that wear, slackness, or take-up adjustments will not affect appreciably the range of travel.

(c) Control system stops shall be capable of withstanding the loads corresponding with the design conditions for the control system.

§ 7.322 *Control locks.* If a device is provided for locking the control system while the rotorcraft is on the ground or water, the provisions of paragraphs (a) and (b) of this section shall apply.

(a) The device shall either automatically disengage when the pilot operates the controls in a normal manner, or it shall limit the operation of the rotorcraft in such a manner that the pilot receives unmistakable warning while on the ground prior to take-off.

(b) Means shall be provided to preclude the possibility of the lock becoming engaged during flight.

§ 7.323 *Static tests*. Tests shall be conducted on control systems to show compliance with limit load requirements in accordance with the provisions of paragraphs (a) through (c) of this section.

(a) The direction of the test loads shall be such as to produce the most severe loading in the control system.

(b) The tests shall include all fittings, pulleys, and brackets used in attaching the control system to the main structure.

(c) Analysis or individual load tests shall be conducted to demonstrate compliance with the special factor requirements for control system joints subjected to angular motion. (See §§ 7.307 and 7.325.)

§ 7.324 *Operation tests*. An operation test shall be conducted for each control system by operating the controls from the pilot compartment with the entire system loaded to correspond with loads specified for the control system. In this test there shall be no jamming, excessive friction, or excessive deflection.

§ 7.325 *Control system details; general*. All details of control systems shall be designed and installed to prevent jamming, chafing, and interference from cargo, passengers, and loose objects. Precautionary means shall be provided in the cockpit to prevent the entry of foreign objects into places where they would jam the control systems. Provisions shall be made to prevent the slapping of cables or tubes against other parts of the rotorcraft. The following detailed requirements shall be applicable with respect to cable systems and joints:

(a) *Cable systems*. (1) Cables, cable fittings, turnbuckles, splices, and pulleys shall be of an acceptable type.

(2) The design of cable systems shall preclude any hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations.

(3) Cables smaller than 1/8 inch diameter shall not be used in the primary control system.

(4) Pulley types and sizes shall correspond to the cables with which they are used. The pulley-cable combinations and strength values specified in ANC-5 shall be used unless shown to be inapplicable for a particular installation.

(5) All pulleys shall be provided with closely fitted guards to prevent the cables being displaced or fouled.

(6) Pulleys shall lie in place passing through the cable withi such limits that the cable does not rub against the pulley flan

(7) Fairleads shall be so installed that they do not cause change in cable direction of more than 3°.

(8) Clevis pins (excluding those not subject to load or motion) retained only by cotter pins shall not be used in the control system.

(9) Turnbuckles attached to parts having angular motio shall be installed to prevent positively any binding througho range of travel.

(10) Provision for visual inspection shall be made at all fairleads, pulleys, terminals, and turnbuckles.

(b) *Joints*. (1) Control system joints subjected to angul motion in push-pull systems, excepting ball and roller bearing systems, shall incorporate a special factor of not less than 3.3 with respect to the ultimate bearing strength of the softest ma used as a bearing.

(2) It shall be acceptable to reduce the factor specified i subparagraph (1) of this paragraph to a value of 2.0 for joints cable control systems.

(3) The manufacturer's static, non-Brinell rating of ball and roller bearings shall not be exceeded.

§ 7.326 *Spring devices*. The reliability of any spring devic used in the control system shall be established by tests simul service conditions, unless it is demonstrated that failure of th spring will not cause flutter or unsafe flight characteristics.

§ 7.327 *Autorotative control mechanism*. The main rotor blade pitch control mechanism shall be arranged to permit rapid entry into autorotative flight in the event of power failure.

§ 7.328 *Power boost systems*. If the rotorcraft is equipped with power boost controls, the design of the control system shall be such that the rotorcraft can be flown and landed safely in the event of any single failure in the power boost system.

LANDING GEAR

§ 7.330 *General*. The requirements of §§ 7.331 through 7.338 shall apply to the complete landing gear.

§ 7.331 *Shock absorbers*. (a) The shock absorbing elements for the main, nose, and rear wheel units shall be substantiated by the tests specified in § 7.332.

(b) The shock absorbing ability of the landing gear in taxiing shall be demonstrated by taxiing tests (see § 7.236).

§ 7.332 *Shock absorption tests*. Drop tests shall be conducted in accordance with paragraphs (a) and (b) of this section to substantiate the landing limit inertia load factor (see § 7.230 (d)) and to demonstrate the reserve energy absorption capacity of the landing gear. The drop tests shall be conducted with the complete rotorcraft or on units consisting of wheel, tire, and shock absorber in their proper relation.

(a) *Limit drop test.* The drop height in the limit drop test shall be 13 inches measured from the lowest point of the landing gear to the ground. A lesser drop height shall be permissible if it results in a drop test contact velocity found by the Administrator to be equal to the greatest probable sinking speed of the rotorcraft at ground contact in power-off landings likely to be made in normal operation of the rotorcraft. In no case shall the drop height be less than 8 inches. If rotor lift is considered (see § 7.230 (c)), it shall be introduced in the drop test by the use of appropriate energy absorbing devices or by the use of an effective mass.

NOTE: In lieu of more rational computations, the following may be employed when use is made of an effective mass:

$$W_e = W \frac{(h + (1 - L)\, d)}{(h + d)}$$

where:

We = the effective weight to be used in the drop test (pounds).

W = *Wm* for main gear units (pounds), equal to the static reaction on the particular unit with the rotorcraft in the most critical attitude; a rational method may be used in computing the main gear static reaction, taking into consideration the distance between the direction of the main wheel reaction and the aircraft center of gravity.

W = *Wn* for nose wheel units (pounds), equal to the vertical component of the ground reaction which would exist at the nose wheel, assuming the mass of the rotorcraft acting at the center of gravity and exerting a force of 1.0 *g* downward and 0.25 *g* forward.

h = specified free drop height (inches).

L = ratio of assumed rotor lift to the rotorcraft weight.

d = deflection under impact of the tire (at the approved inflation pressure) plus the vertical component of the axle travel relative to the drop mass (inches).

(b) *Reserve energy absorption drop test.* The reserve energy absorption capacity shall be demonstrated by a drop test in which the drop height is equal to 1.5 times the drop height prescribed in paragraph (a) of this section, and the rotor lift is assumed to be not greater than 1.5 times the rotor lift used in the limit drop tests, except that the resultant inertia load factor need not exceed 1.5 times the limit inertia load factor determined in accordance with paragraph (a) of this section. In this test the landing gear shall not collapse.

NOTE: The effect of rotor lift may be considered in a manner similar to that prescribed in paragraph (a) of this section.

§ 7.333 *Limit load factor determination*. In determining the rotorcraft inertia load factor "*n*" from the free drop tests specified in § 7.332, the following formula shall be used:

$$n = n_j \frac{W_e}{W} + L;$$

where:

nj = load factor during impact developed on the mass used in the drop tests (i.e., the acceleration dv/dt in g's recorded in the drop tests, plus 1.0). (See § 7.332 (a) for explanation of We, w, and L.)

§ 7.334 *Retracting mechanism* — (a) *General*. (1) The landing gear retracting mechanism, wheel well doors, and supporting structure shall be designed for the loads occurring in the flight maneuvering conditions when the gear is in the retracted position, and for the combination of friction, inertia, and air loads occurring during retraction and extension at any air speed up to the design maximum landing gear extended speed.

(2) The landing gear, the retracting mechanism, and the rotorcraft structure including wheel well doors shall be designed to withstand flight loads, including those in yawed flight, occurring with the landing gear in the extended position at any air speed up to the design maximum landing gear extended speed.

(b) *Landing gear lock*. A positive means shall be provided for the purpose of maintaining the landing gear in the extended position.

(c) *Emergency operation*. When other than manual power for the operation of the landing gear is employed, emergency means for extending the landing gear shall be provided, so that the landing gear can be extended in the event of any reasonably probable failure in the normal retraction system. In any case, the emergency system shall provide for the failure of any single source of hydraulic, electric, or equivalent energy supply.

(d) *Operation test.* Proper functioning of the landing gear retracting mechanism shall be demonstrated by operation tests.

(e) *Position indicator*. When a retractable landing gear is used, means shall be provided for indicating to the pilot when the gear is secured in the extended and in the retracted positions.

(f) *Control*. The location and operation of the landing gear retraction control shall be according to the provisions of § 7.353.

§ 7.335 *Wheels.* Landing gear wheels shall be of an approved type. The maximum static load rating of each wheel shall not be less than the corresponding static ground reaction under the maximum weight of the rotorcraft and the critical center of gravity position. The maximum limit load rating of each wheel shall not be less than the maximum radial limit load determined in accordance with the applicable ground load requirements of this part.

§ 7.336 *Brakes*. A braking device shall be installed, controllable by the pilot and usable during power-off landings, which is adequate to insure:

(a) Counteraction of any normal unbalanced torque when starting or stopping the rotor.

(b) Holding the rotorcraft parked on a 10° slope on a dry, smooth pavement.

§ 7.337 *Tires.* (a) Landing gear tires shall be of a proper fit on the rim of the wheel, and their approved rating shall be such that it is not exceeded under the following conditions:

(1) Rotorcraft weight equal to the maximum design weight.

(2) Load on each main wheel tire equal to the corresponding static ground reaction when considering the critical center of gravity position.

(3) Load on nose wheel tires (to be compared with the dynamic rating established for such tires) equal to the reaction obtained at the nose wheel assuming the mass of the rotorcraft concentrated at the most critical center of gravity and exerting a force of 1.0g downward and 0.25g forward, the reactions being distributed to the nose and main wheels by the principles of statics with the drag reaction at the ground applied only at those wh which have brakes.

§ 7.338 *Skis*. (a) Landing gear skis shall have load rating appropriate to the limit loads determined in accordance with t applicable ground load requirements of this part (see § 7.240)

(b) A stabilizing means shall be provided to maintain th in an appropriate position during flight and shall have suffici strength to withstand the maximum aerodynamic and inertia l to which the ski is subjected.

FLOATS

§ 7.340 *Buoyancy (main floats),* (a) Main floats shall have a buoyancy in excess of that required to support the maximum weight of the rotorcraft in fresh water as follows:

(1) 50 percent in the case of single floats;

(2) 60 percent in the case of multiple floats.

(b) Main floats shall contain at least 5 watertight compartments of approximately equal volume.

§ 7.341 *Float strength.* Floats shall be designed for the conditions set forth in paragraphs (a) and (b) of this section:

(a) *Bag type floats.* Bag type floats shall withstand the maximum pressure differential which might be developed at th maximum altitude for which certification with floats is sought. addition, the floats shall withstand the vertical loads prescrib § 7.245 (a) distributed along the length of the bag over three-quarters of the projected bag area.

(b) *Rigid floats.* Rigid type floats shall withstand the vertical, horizontal, and side loads prescribed in § 7.245. An appropriate load distribution under critical conditions shall b

Personnel and Cargo Accommodations

§ 7.350 *Pilot compartment; general.* (a) The arrangement of the pilot compartment and its appurtenances shall provide safety and assurance that the pilot will be able to perform all of his duties and operate the controls in the correct manner without unreasonable concentration and fatigue.

(b) When provision is made for a second pilot, the rotorcraft shall be controllable with equal safety from both seats.

(c) The pilot compartment shall be constructed to prevent leakage likely to be distracting to the crew or harmful to the structure when flying in rain or snow.

(d) Vibration and noise characteristics of cockpit appurtenances shall not interfere with the safe operation of the rotorcraft.

(e) A passageway between the pilot compartment and the passenger compartment shall be provided. Suitable means shall be provided to prevent passengers from entering the pilot compartment without permission.

§ 7.351 *Pilot compartment vision*—(a) *Nonprecipitation conditions.* (1) The pilot compartment shall be arranged to afford the pilot(s) a sufficiently extensive, clear, and undistorted view for the safe operation of the rotorcraft.

(2) It shall be demonstrated during the day and, where appropriate, during the night by flight tests that the pilot compartment is free of glare and reflection which would tend to interfere with the pilots' vision.

(b) *Precipitation conditions.* (1) Means shall be provided so that the pilot(s) is afforded a sufficiently extensive view to permit safe operation under the following conditions:

(i) In heavy rain at forward speeds up to V_H and

(ii) In the most severe icing condition in which operation of the rotorcraft is approved.

(2) In addition to the means provided in subparagraph (1) of this paragraph, the pilot shall be provided with a window which is openable under the conditions prescribed in subparagraph (1) of this paragraph and which provides the view prescribed in that subparagraph.

§ 7.352 *Pilot windshield and windows.* All glass panes shall be of a nonsplintering safety type.

§ 7.353 *Controls.* (a) All cockpit controls shall be located to provide convenience in operation and in a manner tending to prevent confusion and inadvertent operation. (See also § 7.737.)

(b) The controls shall be so located and arranged with respect to the pilots' seats that there exists full and unrestricted movement of each control without interference from either the cockpit structure or the pilots' clothing when seated. This shall be demonstrated for individuals ranging from 5' 2" to 6' 0" in height.

§ 7.354 *Doors.* (a) Closed cabins shall be provided with at least one adequate and easily accessible external door.

(b) No passenger door shall be so located with respect to the rotor discs as to endanger persons using the door when appropriate operating instructions are employed.

(c) Means shall be provided for locking crew and external passenger doors and for safeguarding against their opening in flight either inadvertently by persons or as a result of mechanical failure. It shall be possible to open external doors from either the inside or the outside of the cabin while the rotorcraft is on the ground. The means of opening shall be simple and obvious and shall be so arranged and marked that it can be readily located and operated.

(d) Reasonable provisions shall be made to prevent the jamming of any external door as a result of fuselage deformation in a minor crash.

(e) Means shall be provided for a direct visual inspection of the locking mechanism by crew members to ascertain whether all external doors, including passenger, crew, service, and cargo doors are fully locked. In addition, visual means shall be provided to signal to appropriate crew members that all normally used external doors are closed and in the fully locked position.

(f) For outwardly opening external doors usable by persons for entrance or egress, an auxiliary safety latching device shall be provided which will prevent the door from coming open in the event of difficulties with the primary latching mechanism. If the door will not meet the requirements of paragraph (c) of this section with the auxiliary safety latching device in place, then suitable operating procedures shall be established to insure that the device shall not be in place during take-off or landing.

§ 7.355 *Seats and safety belts* - (a) *General.* At all stations designated as occupiable during take-off and landing, the seats, belts, harnesses (if used) and adjacent parts of the rotorcraft shall be such that a person making proper use of theses facilities will not suffer serious injury in the emergency landing conditions as a result of inertia forces specified in

§ 7.260. Seats shall be of an approved type (see also § 7.643 concerning safety belts).

(b) *Arrangement.* (1) Passengers and crew shall be afforded protection from head injuries by one of the following means:

(i) Safety belt and shoulder harness which will prevent the head from contacting any injurious object;

(ii) Safety belt and the elimination of all injurious objects within striking radius of the head; or

(iii) Safety belt and a cushioned rest which will support the arms, shoulders, head, and spine.

(2) For arrangements which do not provide a firm handhold on seat backs, hand grips or rails shall be provided along aisles to enable passengers or crew members to steady themselves while using the aisles in moderately rough air.

(3) All projecting objects which would cause injury to persons seated or moving about the rotorcraft in normal flight shall be padded.

(c) *Strength.* All seats and their supporting structure shall be designed for an occupant weight of 170 pounds with due account taken of the maximum load factors, inertia forces, and reactions between occupant, seat, and safety belt or harness corresponding with all relevant flight and ground load conditions, including the emergency landing conditions prescribed in § 7.260. In addition, the following shall apply:

(1) Pilot seats shall be designed for the reactions resulting from the application of pilot forces to the flight controls as prescribed in § 7.225.

(2) In determining the strength of the seat attachments to the structure and the safety belt or shoulder harness (if installed) attachments to the seat or structure, the inertia forces specified in § 7.260 (a) shall be multiplied by a factor of 1.33.

§ 7.356 *Cargo and baggage compartments.* (See also § 7.382.) (a) Each cargo and baggage compartment shall be designed for the placarded maximum weight of contents and the critical load distributions at the appropriate maximum load factors corresponding with all specified flight and ground load conditions, excluding the emergency landing conditions of § 7.260.

(b) Provision shall be made to prevent the contents in the compartments from becoming a hazard by shifting under the loads specified in paragraph (a) of this section.

(c) Provision shall be made to protect the passengers and crew from injury by the contents of any compartment when the ultimate inertia force acting forward is 4g.

§ 7.357 *Emergency evacuation.* Crew and passenger areas shall be provided with emergency evacuation means to permit rapid egress in the event of crash landings, whether with the landing gear extended or retracted, taking into account the possibility of the rotorcraft being on fire. Passenger entrance, crew, and service doors shall be considered as emergency exits if they meet the applicable requirements of this section.

(a) *Flight crew emergency exits.* Flight crew emergenc exits shall be located in the flight crew area on both sides of t rotorcraft or as a top hatch to provide for rapid evacuation. S exits shall not be required on small rotorcraft where the Administrator finds that the proximity of passenger emergenc exits to the flight crew area renders them convenient and read accessible to the flight crew.

(b) *Passenger emergency exits; type and location.* The types of exits and their location shall be as follows:

(1) *Type 1.* A rectangular opening of not less than 24 ir wide by 48 inches high, with corner radii not greater than 4 ir located in the passenger area in the side of the fuselage at flo and as far away as practicable from areas which might becom potential fire hazards after a crash.

(2) *Type II.* Same as Type I (subparagraph (1) of this paragraph) except that the opening is not less than 20 inches by 44 inches high.

(3) *Type III.* A rectangular opening of not less than 20 inches wide by 36 inches high, with corner radii not greater th inches, located in the passenger area in the side of the fusela as far away as practicable from areas which might become po fire hazards after a crash.

(4) *Type IV.* A rectangular opening of not less than 19 inches wide by 26 inches high, with corner radii not greater th inches, located in the side of the fuselage with a step-up insic rotorcraft of not more than 29 inches.

NOTE: Larger openings than those specified in paragrapl of this section will be acceptable, whether or not of rectangul shape, provided the specified rectangular openings can be in therein, and further provided that the base of the opening aff flat surface not less than the width specified.

(c) *Passenger emergency exits; number required.* Emergency exits of the type and located as prescribed in paragraph (b) of this section shall be accessible to the passengers, and shall be provided in accordance with the following table:

Passenger seating capacity	Emergency exits required on each side of fuselage			
	Type I	Type II	Type III	Type IV
1 to 19 inclusive--------	-----	------	1	-----
20 to 39 inclusive------	-----	1	------	1
40 to 69 inclusive------	1	------	------	1

In addition to the number of exits required for the side of the fuselage, openings shall be provided in other parts of the fuselage (top, bottom, or ends) so that, in the event of a crash landing in which the fuselage comes to rest on its side, emergency exits shall be available for egress. When it can be satisfactorily demonstrated that the configuration of the rotorcraft is such that the probability of the rotorcraft rolling over and coming to rest on the side of the fuselage after a crash landing is extremely remote, it shall be acceptable to provide emergency exits in the side of the fuselage only.

(d) *Emergency exit arrangement.* (1) Emergency exits shall consist of movable doors or hatches in the external walls of the fuselage and shall provide an unobstructed opening to the outside.

(2) All emergency exits shall be openable from the inside and from the outside.

(3) The means of opening emergency exits shall be simple and obvious and shall not require exceptional effort of a person opening them.

(4) Means shall be provided for locking each emergency exit and for safe-guarding against opening in flight either inadvertently by persons or as a result of mechanical failure.

(5) Provision shall be made to minimize the possibility of jamming of emergency exits as a result of fuselage deformation in a minor crash landing.

(6) For all emergency exits other than Type IV located above a wing (see paragraph (b) of this section) which are more than 6 feet from the ground with the rotorcraft on the ground and the landing gear extended, acceptable means shall be provided to assist the occupants in descending to the ground.

(7) The proper functioning of emergency exit installations shall be demonstrated by test.

(e) *Emergency exit marking.* (1) All emergency exits, their means of access, and their means of opening shall be marked conspicuously. The identity and location of emergency exits shall be recognizable from a distance equal to the width of the cabin. The location of the emergency exit operating handle and the instructions for opening shall be marked on or adjacent to the emergency exit and shall be readable from a distance of 30 inches.

(2) A source or sources of light, with an energy supply independent of the main lighting system, shall be installed to illuminate all emergency exit markings. Such lights shall be designed to function automatically in a crash landing and shall also be operable manually.

(3) All emergency exits and their means of opening shall be marked on the outside of the rotorcraft for guidance of rescue personnel.

(f) *Emergency exit access.* Passage-ways between individual compartments of the passenger area and passageways leading to Type I and Type II emergency exits (see paragraph (b) of this section) shall be unobstructed and shall not be less than 20 inches wide. Adjacent to emergency exits where assisting means are required by paragraph (d) (6) of this section, there shall be sufficient additional space to allow a crew member to assist in the evacuation of passengers without reduction in the unobstructed width of the passageway to such exit.

(g) *Width of main aisle.* The main passenger aisle at any point between seats shall be not less than 15 inches wide up to a height above the floor of 25 inches and not less than 20 inches wide above the height.

§ 7.358 *Ventilation.* (a) All passenger and crew compartments shall be ventilated and crew compartments shall be provided with a sufficient amount of fresh air to enable crew members to perform their duties without undue discomfort or fatigue.

NOTE: A fresh air supply of 10 cubic feet per minute is considered a minimum for each crew member.

(b) Crew and passenger compartment air shall be free from harmful or hazardous concentrations of gases or vapors. The concentration of carbon monoxide shall not exceed 1 part in 20,000 parts of air under conditions of forward flight. For other configurations of operation, suitable operating restrictions shall be provided if the carbon monoxide concentration exceeds this value.

(c) Provisions shall be made to insure the conditions prescribed in paragraph (b) of this section in the event of reasonably probable failures of the ventilating, heating, or other systems and equipment.

NOTE: Examples of acceptable provisions include secondary isolation, integral protective devices, and crew warning and shut-off provisions for equipment the malfunctioning of which could introduce harmful or hazardous quantities of smoke or gases.

§ 7.359 *Heaters.* Combustion heaters shall be of an approved type and shall comply with the fire protection requirements of § 7.383. Engine exhaust heaters shall comply with the provisions of § 7.467 (c) and (d).

Fire Prevention

§ 7.380 *General.* Compliance shall be shown with the fire prevention requirements of §§ 7.381 through 7.385. Additional fire prevention requirements are prescribed in Subpart E, Powerplant Installation, and Subpart F, Equipment.

(a) *Hand fire extinguishers.* Hand fire extinguishers shall be of an approved type. The types and quantities of extinguishing agents shall be appropriate for the type of fires likely to occur in the compartments where the extinguishers are intended for use. Extinguishers intended for use in personnel compartments shall be such as to minimize the hazard of toxic gas concentrations.

(b) *Built-in fire extinguishers.* Where a built-in fire extinguishing system is required, its capacity in relation to the compartment volume and ventilation rate shall be sufficient to combat any fire likely to occur in the compartment. All built-in fire extinguishing systems shall be so installed that any extinguishing agent likely to enter personnel compartments will not be hazardous to the occupants and that any discharge of the extinguisher cannot result in structural damage.

§ 7.381 *Cabin interiors.* All compartments occupied or used by the crew or passengers shall comply with the provisions of paragraphs (a) through (f) of this section.

(a) The materials in no case shall be less than flash-resistant.

(b) The wall and ceiling linings, the covering of all upholstery, floors, and furnishings shall be flame-resistant.

(c) Compartments where smoking is to be permitted shall be equipped with ash trays of the self-contained type which are completely removable. All other compartments shall be placarded against smoking.

(d) All receptacles for used towels, paper, and waste shall be of fire-resistant materials and shall incorporate covers or other provisions for containing possible fires.

(e) At least one hand fire extinguisher shall be provided for use by the flight crew.

(f) In addition to the requirements of paragraph (e) of this section, at least the following number of hand fire extinguishers conveniently located for use in passenger compartments shall be provided according to the passenger capacity of the rotorcraft:

Passenger Capacity	Minimum number of hand fire extinguishers
6 or less--------------------	0
7 through 30 -------------	1
31 through 60------------	2

§ 7.382 *Cargo and baggage compartments.* (a) Cargo and baggage compartments shall be constructed of or comple lined with fire-resistant material. Compartments shall include controls, wiring, lines, equipment, or accessories, the damage failure of which would affect the safe operation of the rotorcr unless such items are shielded, isolated, or otherwise protect that they cannot be damaged by movement of cargo in the compartment, and so that any breakage or failure of such item not create a fire hazard. Design of inaccessible compartment sealing of these compartments shall be such as to contain ca compartment fires for a period of time sufficient to permit lan and safe evacuation of the occupants.

NOTE: For compartments having a volume not in excess 500 cubic feet, an airflow of not more than 1,500 cubic feet pe hour is considered acceptable. For larger compartments less airflow may be applicable.

(b) Cargo and baggage compartments shall be designe provided with detection devices to insure detection of fires b crew member while at his proper station, and to preclude the entrance of harmful quantities of smoke, flame, etc., into crew passenger compartments.

(c) If compartments are intended to be accessible in flig protective breathing equipment shall be available for the use appropriate crew member (see § 7.646).

(d) Compliance with the provisions of this section which refer to fire detection and the entry of hazardous quantities of smoke, extinguishing agents, or other noxious gases into the crew and passenger compartments shall be demonstrated in flight.

§ 7.383 *Combustion heater fire protection* - (a) *Combustion heater fire zones.* The following shall be considered as combustion heater fire zones and shall be protected against fire in accordance with the applicable provisions of §§ 7.480 through 7.486 and § 7.489:

(1) Region surrounding the heater, if such region contains any flammable fluid system components including the heater fuel system which might be damaged by heater malfunctioning or which, in case of leakage or failure, might permit flammable fluids or vapors to reach the heaters.

(2) That portion of the ventilating air passage which surrounds the combustion chamber, except that this area need not be provided with an extinguishing system if the passage is so constructed that it will contain and withstand any fire which may occur within the passage without damage to other rotorcraft components.

(b) *Ventilating air ducts.* (1) Ventilating air ducts which pass through fire zones shall be of fireproof construction.

(2) Unless isolation is provided by the use of fireproof valves or other equivalently effective means, the ventilating air duct downstream of the heater shall be of fireproof construction for a sufficient distance to assure that any fire originating from within the heater can be contained within the duct.

(3) Portions of ventilating ducts passing through regions in the rotorcraft where flammable fluid systems are located shall be so constructed or isolated from such systems that failure or malfunctioning of the flammable fluid system components cannot introduce flammable fluids or vapors into the ventilating airstream.

(c) *Combustion air ducts.* (1) Combustion air ducts shall be of fireproof construction for a distance sufficient to prevent damage from backfiring or reverse flame propagation.

(2) Combustion air ducts shall not communicate with the ventilating airstream unless it is demonstrated that flames from backfires or reverse burning cannot enter the ventilating airstream under any conditions of ground or flight operation including conditions of reverse flow or malfunctioning of the heater or its associated components.

(3) Combustion air ducts shall not restrict prompt relief of backfires which can cause heater failure due to pressures generated within the heater.

(d) *Heater controls; general.* Provisions shall be made to prevent hazardous accumulations of water or ice on or within any heater control components, control system tubing, or safety controls.

(e) *Heater safety controls.* (1) In addition to the components provided for normal continuos control of air temperature, airflow, and fuel flow, means independent of such components shall be provided with respect to each heater to shut off automatically that heater’s ignition and fuel supply at a point remote from the heater when the heat exchanger temperature or ventilating air temperature exceeds safe limits or when either the combustion airflow or the ventilating airflow becomes inadequate for safe operation. The means provided for this purpose for any individual heater shall be independent of all components serving other heaters, the heat output of which is essential to the safe operation of the rotorcraft. The means shall also be such that the heater will remain off until restarted by the crew.

(2) Warning means shall be provided to indicate to the crew when a heater, the heat output of which is essential to the safe operation of the rotorcraft, has been shut off by the operation of the automatic means prescribed in subparagraph (1) of this paragraph.

(f) *Air intakes.* Combustion and ventilating air intakes shall be so located that no flammable fluids or vapors can enter the heater system under any conditions of ground or flight operation either during normal operation or as a result of malfunctioning, failure, or improper operation of other rotorcraft components.

(g) *Heater exhaust.* Heater exhaust systems shall comply with the provisions of § 7.467 (a) and (b). In addition, the following shall apply:

(1) Exhaust shrouds shall be sealed so that flammable fluids and hazardous quantities of vapors cannot reach the exhaust systems through joints.

(2) Exhaust systems shall not restrict the prompt relief of backfires which can cause heater failure due to pressures generated within the heater.

(h) *Heater fuel systems.* Heater fuel systems shall comply with all portions of the powerplant fuel system requirements which affect safe heater operation. In addition, heater fuel system components within the ventilating airstream shall be protected by shrouds so that leakage from such components cannot enter the ventilating airstream.

(i) *Drains.* Means shall be provided for safe drainage of fuel accumulations which might occur within the combustion chamber or the heat exchanger. Portions of such drains which operate at high temperatures shall be protected in the same manner as heater exhausts (see paragraph (g) of this section). Drains shall be protected against hazardous ice accumulations in flight and during ground operation.

§ 7.384 *Fire protection of structure, controls, and other parts* - (a) *Category A.* All structure, controls, rotor mechanism, and other parts essential to controlled flight and landing of the rotorcraft which would be affected by powerplant fires shall be of fireproof construction.

(b) *Category B.* All structure, controls, rotor mechanism, and other parts essential to a controlled landing of the rotorcraft which would be affected by powerplant fires either shall be of fireproof construction or shall be otherwise protected, so that they can perform their essential functions for at least 5 minutes under all foreseeable powerplant fire conditions. (See also §§ 7.480 and 7.483 (a).)

§ 7.385 *Flammable fluid fire protection.* In areas of the rotorcraft where flammable fluids or vapors might be liberated by leakage or failure in fluid systems, design precautions shall be taken to safeguard against the ignition of such fluids or vapors due to the operation of other equipment or to control any fire resulting from such ignition.

MISCELLANEOUS

§ 7.390 *Leveling marks.* Reference marks shall be provided for use in leveling the rotorcraft to facilitate weight and balance determinations on the ground.

§ 7.391 *Ballast provisions.* Ballast provisions shall be so designed and constructed as to prevent the inadvertent shifting of the ballast in flight. (See also §§ 7.105, 7.738 (a), and 7.741 (c).)

§ 7.392 *Ice protection.* If certification for flight in icing conditions is desired, the rotorcraft shall be capable of operating safely in the range of conditions applicable to the operating limitations of the design.

SUBPART E—POWERPLANT INSTALLATION

GENERAL

§ 7.400 *Scope and general design.* The powerplant installation shall be considered to include all components of the rotorcraft which are necessary for its propulsion with the exception of the structure of the main and auxiliary rotors. It shall also be considered to include all components which affect the control of the major propulsive units or which affect their safety of operation between normal inspections or overhaul periods. (See §§ 7.604 and 7.613 for instrument installation and marking.) The general provisions of paragraphs (a) through (d) of this section shall be applicable.

(a) Reciprocating engine installations shall comply with provisions of this subpart. Turbine engine installations shall comply with such of the provisions of this subpart as are fou applicable to the specific type of installation and such other requirements as may be deemed necessary by the Administra

(b) All components of the powerplant installation shall constructed, arranged, and installed in a manner which will as their continued safe operation between normal inspections o overhaul periods.

(c) Accessibility shall be provided to permit such inspe and maintenance as is necessary to assure continued airwort

(d) Electrical interconnections shall be provided to prev the existence of differences of potential between major comp of the powerplant installation and other portions of the rotor

§ 7.401 *Engines* - (a) *Type certification.* All engines shall be type certificated in accordance with the provisions of 13 of this subchapter.

(b) *Category A; engine isolation.* The powerplants sha be arranged and isolated each from the other to permit operat at least one configuration in such a manner that the failure or malfunctioning of any engine, or the failure of any system of rotorcraft which can affect an engine, will not prevent the continued safe operation of the remaining engine(s) or requir immediate action by crew members for their continued safe operation.

(c) *Category A; control of engine rotation.* Means shall be provided for stopping and restarting the rotation of a engine individually in flight. All components provided for thi purpose which are located on the engine side of the fire wall which might be exposed to fire shall be of fire-resistant construction unless more than one means is available for this purpose and provided further that the duplicate controls are located that all are not likely to be damaged at the same time of fire.

§ 7.402 *Engine vibration.* The engine shall be installed to preclude harmful vibration of any of the engine parts or of any of the components of the rotorcraft. It shall be demonstrated by means of a vibration investigation that the addition of the rotor and the rotor drive system to the engine does not result in modification of engine vibration characteristics to the extent that the principal rotating portions of the engine are subjected to excessive vibratory stresses.

ROTOR DRIVE SYSTEM

§ 7.403 *Rotor drive system* - (a) *General.* The rotor drive system shall be considered to include all parts necessary to transmit power between the engine(s) and the main and/or auxiliary rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assembly, overrunning and other clutches, supporting bearings for shafting, and any attendant accessory pads or drives. Cooling fans which are not certificated as part of the engine shall also be considered a part of the rotor drive system.

(b) *Arrangement.* (1) The rotor drive system of a multiengine rotorcraft shall be so arranged that all rotors necessary for operation and control of the rotorcraft will continue to be driven by the remaining engine(s) in the event of failure of any of the engines.

(2) *Category B:* On single-engine rotorcraft the rotor drive system shall be so arranged that all rotors necessary for control of the rotorcraft in autorotative flight will continue to be driven by the main rotor(s) after disengagement of the engine from the main and auxiliary rotors.

(3) The rotor drive system shall incorporate a unit for each engine which will automatically disengage the engine from the drive system in the event of a power failure of the engine.

(4) If a torque limiting device is employed in the rotor drive system (see § 7.250 (f)), such device shall be located to permit continued control of the rotorcraft after the device becomes operative.

(5) On rotorcraft employing rotors which must be phased for intermeshing purposes, the rotor drive system shall provide constant and positive phase relationship under all operating conditions. If a rotor defacing device is incorporated, means shall be provided to insure that the rotors are locked in proper phase prior to operation.

§ 7.404 *Rotor brakes.* If a means is provided to control the rotation of the rotor drive system independent of the engine, the limitations on the use of such means shall be specified, and the control for this means shall be guarded to prevent inadvertent operation.

§ 7.405 *Rotor drive system and control mechanism tests* - (a) *Endurance tests* - (1) *General.* The rotor drive system and rotor control mechanism shall be tested for not less than 200 hours. The test shall be conducted on the rotorcraft and the power shall be absorbed by the actual rotors to be installed. The endurance tests shall be conducted in 10-hour test cycles composed of the tests prescribed in subparagraphs (2) through (10) of this paragraph. Compliance with the endurance tests prescribed in this paragraph will be accepted for helicopter engine certification in lieu of the endurance testing specified in Part 13 of this subchapter. (The other phases of helicopter engine certification such as vibration, calibration, detonation, operation, and engine inspection will of course require compliance in accordance with Part 13 of this subchapter.)

(2) *Take-off power run.* The take-off power run shall consist of one hour of alternate runs of 5 minutes at take-off power and speed, and 5 minutes at as low an engine idle speed as practicable. The engine shall be declutched from the rotor drive system and the rotor brake, if furnished and so intended, shall be applied during the first minute of the idle run. During the remaining 4 minutes of the idle run, the clutch shall be engaged so that the engine drives the rotors at the minimum practical rpm. Acceleration of the engine and the rotor drive system shall be accomplished at the maximum rate. When declutching the engine, it shall be decelerated at a rate sufficiently rapid to permit the operation of the over-running clutch. In the absence of a take-off rating, maximum continuous power and speed shall be substituted for take-off power and speed.

(3) *Maximum continuous run.* Three hours of continuous operation at maximum continuous power and speed as follows:

(i) During the run, the main rotor controls shall be operated at a minimum of 15 times each hour through the main rotor pitch positions of full vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust component, except that the control movements need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight.

(ii) The directional controls shall be operated at a minimum of 15 times each hour through the control extremes of maximum right turning torque, neutral torque as required by the power applied to the main rotor, and maximum left turning torque.

(iii) Each control position shall be held at maximum for at least 10 seconds and the rate of change of control position shall be at least as rapid as for normal operation.

(4) *90 percent maximum continuous run.* One hour of continuous operation at 90 percent maximum continuous power at maximum continuous speed.

(5) *80 percent maximum continuous run.* One hour of continuous operation at 80 percent maximum continuous power and speed.

(6) *60 percent maximum continuous run.* Two hours of continuous operation at 60 percent maximum continuous power at minimum desired cruising speed or at 90 percent maximum continuous speed, whichever speed is lower.

(7) *Engine malfunctioning run.* It shall be determined whether malfunctioning of such components as the engine fuel or ignition systems or unequal power output from the various engines can result in dynamic conditions which might be detrimental to the drive system. If so, a suitable number of hours of operation shall be accomplished under such conditions, one hour of which shall be included in each cycle, and the remaining hours accomplished at the conclusion of the 20 cycles. If no detrimental condition results, an additional hour of operation as prescribed in subparagraph (2) of this paragraph shall be substituted.

(8) *Overspeed run.* One hour of continuous operation at 110 percent maximum continuous speed at maximum continuous power. In the event that the engine(s) installed are limited by the manufacturer to an overspeed of less than 110 percent of maximum continuous speed for the periods required, the speed employed shall be the highest speed permissible with the engine(s) involved.

(9) *Rotor control positions.* Whenever the rotor controls are not being cycled during the tie-down tests, the rotor shall be operated to produce each of the maximum thrust positions for the percentages of test time as follows, except that the control positions need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight, using the procedures of subparagraph (3) of this paragraph:

(i) Full vertical thrust, 20 percent.

(ii) Forward thrust component, 10 percent.

(iii) Right thrust component, 10 percent.

(iv) Left thrust component, 10 percent.

(v) Aft thrust component, 10 percent.

(10) *Clutch and brake engagements.* A total of at least 400 clutch and brake engagements including the engagements of paragraph (a) (2) of this section shall be made during the take-off power runs and, as necessary, at each change of power and speed throughout the test. In each clutch engagement, the shaft on the driven side of the clutch shall be accelerated from rest. The clutch engagements shall be accomplished at the speed and by the method prescribed in the operations manual. During deceleration afte clutch engagement, the engine(s) shall be stopped rapidly en allow the engine(s) to be automatically disengaged from the r and/or rotor-drive(s). If a rotor brake is installed for the purp stopping the rotor, the clutch, during brake engagements, sha disengaged above 40 percent maximum continuous rotor spe the rotor(s) allowed to decelerate to 40 percent maximum continuous rotor speed at which time the rotor brake shall be applied. If the clutch design does not permit stopping the ro with the engine running, or if no clutch is provided, the engin be stopped before each application of the rotor brake, and th immediately restarted after the rotors have stopped.

(b) *Overspeed test.* After completion of the 200-hour tie down test and without intervening major disassembly, the ro drive system shall be subjected to 50 overspeed runs, each 3 seconds in duration at 120 percent maximum continuous spee Overspeed runs shall be alternated with stabilizing runs of 1 t minutes duration each at from 60 to 80 percent maximum continuous speed. Acceleration and deceleration shall be accomplished in a period not longer than 10 seconds, and the for changing speeds shall not be deducted from the specified for the overspeed runs. Overspeed runs should be made with rotor(s) in the flattest pitch at which smooth operation can be obtained. In the event that the engine(s) installed is limited b engine manufacturer to an overspeed of less than 120 percen maximum continuous speed for the periods required, the spee employed shall be the highest speed permissible with the eng involved.

(c) *Critical component reliability tests.* Components within the rotor drive system, the failure of which will result i uncontrolled landing, components essential to the phasing o rotors on multirotor rotorcraft, or as a driving link for essenti control of rotors in autorotation, and components common to than one engine or multiengine rotorcraft, shall be designed t a level of safety equivalent to the main rotors.

Components which are affected by flight maneuvering and gust loads shall be additionally investigated for the same flight conditions as the main rotor(s). The service life of such parts shall be determined by fatigue tests or by other methods found acceptable by the Administrator.

(d) *Special tests.* Rotor drive systems designed to operate at two or more gear rations shall be subjected to special testing and durations found necessary by the Administrator to substantiate the airworthiness of the rotor drive system.

(e) *Category A; gear box bench tests.* Each gear box employed in the rotor drive system shall be tested for 150 hours at 110 percent of its maximum continuous power and speed. The components employed in this test need not be the same as those employed in the tests of paragraph (a) of this section.

§ 7.406 *Additional tests.* Such additional dynamic, endurance, and operational tests or vibratory investigations shall be conducted as are found necessary by the Administrator to substantiate the airworthiness of the rotor drive mechanism.

§ 7.407 *Critical shafting speeds.* An investigation shall be made to determine that the critical speeds of all shafting lie outside the range permissible engine speeds under idling, power-on, and autorotative conditions. If critical vibration conditions (persistent or momentary) are found in the entire range of operations from and including clutch engagement to maximum overspeed, either during acceleration or deceleration, it shall be demonstrated in the rotorcraft that such vibration is within safe limits. Such demonstration may be made during the endurance testing (see § 7.405 (a)), in which case the test schedule may be altered to include the critical vibratory conditions in lieu of equivalent time in appropriate portions of the endurance test procedure.

§ 7.408 *Shafting joints.* All universal joints, slip joints, and other shafting joints shall have provision for lubrication, unless it is demonstrated that lack of lubrication will have no adverse effect on the operation of the rotorcraft.

FUEL SYSTEM OPERATION AND ARRANGEMENT

§ 7.410 *General.* (a) The fuel system shall be constructed and arranged in such a manner as to assure a flow of fuel to each engine at a rate and pressure which have been established for proper engine functioning under all normal conditions, including all maneuvers for which the rotorcraft is intended. (For fuel system instruments see § 7.604.)

(b) The fuel system shall be so arranged that no one engine or fuel pump can draw fuel from more than one tank at a time unless means are provided to prevent introducing air into the system.

§ 7.411 *Fuel system independence* - (a) *Category A.* The design of the fuel system shall comply with the requirements of § 7.401 (b). Unless other provisions are made in compliance with this requirement, the fuel system shall be arranged to permit the supply of fuel to each engine through a system independent of any portion of a system supplying fuel to any other engine.

(b) *Category B.* The design of the fuel system for multiengine rotorcraft shall be arranged to permit supplying fuel to each engine through a system independent of all portions of systems supplying fuel to the other engines, except that separate fuel tanks need not be provided for each engine.

§ 7.412 *Fuel lines in personnel and cargo compartments.* (a) Fuel lines shall not pass through portions of the rotorcraft intended to carry personnel or cargo, unless they are so located or protected by drained and ventilated shrouds or other means which will assure that in case of leakage, fuel and fumes will be carried safely overboard. Means shall be provided to permit the flight personnel to shut off the supply of fuel to such lines without affecting operation of more than one engine.

(b) Lines which can be isolated from the remainder of the fuel system by means of valves at each end shall incorporate provisions for the relief of excessive pressures which might result from exposure of the isolated line to high ambient temperatures.

§ 7.413 *Fuel flow and feed.* (a) The fuel supply system shall be arranged so that, insofar as practicable, the entire fuel supply can be utilized in the maximum inclinations of the rotorcraft for any sustained conditions of flight and so that the feed ports will not be uncovered during normal maneuvers involving moderate rolling or sideslipping. On rotorcraft with more than one fuel tank, the system shall feed promptly when the fuel supply becomes low in one tank and another tank is turned on (see § 7.438).

(b) The ability of the fuel system to provide the required fuel flow rate shall be demonstrated when the rotorcraft is in the attitude which represents the most adverse sustained condition, from the standpoint of fuel feed, which the rotorcraft is designed to attain. The demonstration may be accomplished by a ground test of the rotorcraft or on a representative operating mock-up of the fuel system. The following conditions are applicable to such demonstration:

(1) Category A: The critical attitude (or attitudes) selected shall be verified by a flight demonstration which takes into consideration all operating speeds, power settings, accelerated maneuvers, and engine inoperative conditions.

(2) The quantity of fuel in the tank being considered shall not exceed the amount established as the unusable fuel supply for that tank, as determined by demonstrating compliance with the provisions of § 7.416 (see also §§ 7.418 and 7.613 (b)), together with whatever minimum quantity of fuel it may be necessary to add for the purpose of conducting the flow test.

(3) The fuel shall be delivered to the engine at a pressure not less than the minimum inlet pressure established for proper engine operation in accordance with Part 13 of this subchapter.

(4) If a fuel flowmeter is provided, the meter shall be blocked during the flow test and the fuel shall flow through the meter by-pass.

(c) The fuel flow rate required for the demonstration specified in paragraph (b) of this section shall be as follows:

(1) For gravity feed systems: The fuel flow rate shall be 150 percent of the actual take-off power fuel consumption of the engine.

(2) For pump systems: The fuel flow rate shall be 0.9 pound per hour for each rated take-off horsepower or 125 percent of the actual take-off fuel consumption of the engine, whichever is greater.

§ 7.414 *Pump systems.* (a) The fuel flow rate specified in § 7.413 (c) shall be applicable to both the primary engine-driven pump and to emergency pumps. The fuel flow rate shall be available when the pump is running at the speed at which it normally would be operating during take-off. In the case of hand-operating pumps, the speed required shall be not more than 60 complete cycles (120 single strokes) per minute.

(b) Emergency pumps shall be provided to permit supplying all engines with fuel in case of failure of any one main fuel pump, except in the case of installations in which the only fuel pump necessary is an engine fuel injection or fuel metering pump which is approved as an integral part of the engine.

(c) Category A: If the arrangement of the fuel system necessitates a fuel boost pump to maintain operating fuel flow and pressure for the range of altitudes and temperatures in which flight is expected, a duplicate boost pump shall be provided to serve as an emergency pump in case of failure of the main boost pump. Each pump shall be capable of supplying fuel flow at the rate specified in § 7.413 (c).

(d) Category A: Where the provisions of paragraph (c) of this section are applicable, and both boost pumps are dependent upon a common source of power, it shall be possible with these components inoperative to maintain cruising fuel flow and pressure for all engines. The limiting weights, speeds, and altitudes shall be demonstrated and the results recorded in the operating procedures portion of the Rotorcraft Flight Manual.

§ 7.415 *Transfer systems.* The provisions of § 7.413 shall apply to transfer systems, except that the required fuel flow ra for the engine or engines involved shall be established upon basis of maximum continuous power and its corresponding s

§ 7.416 *Determination of unusable fuel supply.* The unusable fuel supply in each tank shall be that quantity at wh the first evidence of malfunctioning occurs in any sustained f condition at the most critical weight and center of gravity pos within the approved limitations. The unusable fuel supply sh determined for each tank used in normal operation. (See also §§7.104 and 7.613 (b).)

§ 7.417 *Fuel system hot weather operation.* (a) The fuel system shall be so arranged as to minimize the possibility the formation of vapor in the system under all normal conditi operation. Rotorcraft with suction lift fuel systems or system which have features likely to produce vapor shall be demonst to be free from vapor lock when using fuel at a temperature o 110°F. under critical operating conditions.

(b) Category A: To prove satisfactory hot weather operation the rotorcraft shall be climbed from the altitude of t airport chosen by the applicant to an altitude of 5,000 feet ab the terrain, or to the altitude at which the rotorcraft is expecte operate, whichever is greater. There shall be no evidence of lock or other malfunctioning. The climb test shall be conduct under the following conditions:

(1) All engines shall operate at maximum continuous po except that take-off power shall be used at the beginning of t demonstration for the maximum time interval for which take-o power is approved for use on the rotorcraft.

(2) The weight shall be with full fuel tanks, minimum cre and only such ballast as is required

to maintain the center of gravity within allowable limits.

(3) The speed of climb shall be the speed for best rate of climb under the conditions of the test.

(4) The fuel temperature shall be not less than 110°F. at the beginning of the demonstration.

(c) Category A: The test prescribed in paragraph (b) of this section shall be performed either in flight or on the ground closely simulating flight conditions. If a flight test is performed in weather sufficiently cold to interfere with the proper conduct of the test, the fuel tank surfaces, fuel lines, and other fuel system parts subjected to cooling action from cold air shall be insulated to simulate, insofar as practicable, flight in hot weather.

§ 7.418 *Flow between interconnected tanks.* (a) Where tank outlets are interconnected and permit flow through the interconnection due to gravity or flight accelerations, it shall not be possible for fuel to flow between tanks in quantities sufficient to cause an overflow of fuel from the tank vent when the rotorcraft is operated in any sustained flight condition.

(b) If it is possible to pump fuel from one tank to another in flight, the design of the fuel tank vents and the fuel transfer system shall be such that structural damage to tanks will not occur in the event of overfilling. In addition, means shall be provided to warn the crew before overflow through the vents occurs.

FUEL TANK CONSTRUCTION AND INSTALLATION

§ 7.420 *General.* (a) Fuel tanks shall be capable of withstanding without failure all vibrations, inertia, fluid, and structural loads to which they may be subjected in operation.

(b) Fuel tanks and their installation shall be designed or protected so as to retain the fuel supply without leakage when the rotorcraft is subjected to the emergency landing conditions specified under § 7.260.

(c) Flexible fuel tank liners shall be of an approved type or shall be shown to be suitable for the particular application.

(d) Integral type fuel tanks shall be provided with facilities for inspection and repair of the tank interior.

§ 7.421 *Fuel tank tests.* (a) Fuel tanks shall be capable of withstanding the following pressure tests without failure or leakage. It shall be acceptable to apply the pressures in a manner simulating the actual pressure distribution in service (where this is practicable).

(1) Conventional metal tanks, non-metallic tanks the walls of which are not supported by the rotorcraft structure, and integral tanks shall be submitted to a pressure of 3.5 psi unless the pressure developed during the maximum limit acceleration or emergency deceleration (see § 7.260) of the rotorcraft with a full tank exceeds this value, in which case a hydrostatic head, or equivalent test, shall be applied to duplicate the acceleration loads insofar as possible, except that the pressure need not exceed 3.5 psi on surfaces not exposed to the acceleration loading.

(2) Nonmetallic tanks the walls of which are supported by the rotorcraft structure shall be submitted to the following tests:

(i) A pressure test of at least 2.0 psi. The test may be conducted on the tank alone in conjunction with the test specified in subdivision (ii) of this subparagraph.

(ii) A pressure test, with the tank mounted in the rotorcraft structure, equivalent to the load developed by the reaction of the contents, when the tanks are full, during the maximum limit acceleration or emergency declaration (see § 7.260) of the rotorcraft, except that the pressure need not exceed 2.0 psi on the surfaces not exposed to the acceleration loading.

(b) Tanks with large unsupported or unstiffened flat area or other design or construction features the failure or deformation of which could cause fuel leakage shall be capable of withstanding the following test, or other equivalent test, without leakage or failure:

(1) The complete tank assembly together with its supports shall be subjected to a vibration test when mounted in a manner simulating the actual installation.

(2) The tank assembly shall be vibrated for 25 hours while filled two-thirds full of water or any suitable fluid. The amplitude of vibration shall not be less than one thirty-second of an inch, unless otherwise substantiated.

(3) The frequency of vibration shall be 90 percent of the maximum continuous rated speed of the engine unless some other frequency within the normal operating range of speeds of the engine or rotor system is more critical, in which case the latter speed shall be employed and the time of test shall be adjusted to accomplish the same number of vibration cycles.

(4) During the test, the tank assembly shall be rocked at the rate of 16 to 20 complete cycles per minute through an angle of 15° on either side of the horizontal (30° total) about the most critical axis for 25 hours. If motion about more than one axis is likely to be critical, the tank shall be rocked about each axis for 12 1/2 hours.

§ 7.422 *Fuel tank installation.* (a) The method of support for fuel tanks shall not permit harmful concentrations of loads, resulting from the weight of the fuel in the tank, on unsupported tank surfaces. The following shall be applicable:

(1) Pads shall be provided, if necessary, to prevent chafing between the tank and its supports.

(2) Materials employed for padding shall be nonabsorbent or shall be treated to prevent the absorption of fluids.

(3) If flexible tank liners are employed they shall be so supported that the liner is not required to withstand fluid loads.

(4) Interior surfaces of tank compartments shall be smooth and free of projections which could cause wear of the liner, unless provisions are made for protection of the liner at such points or unless they construction of the liner itself provides such protection.

(b) Spaces adjacent to the surfaces of the tank shall be ventilated consistent with the size of the compartments to avoid accumulation of fuel or fumes in these spaces due to minor leakage. If the tank is in a sealed compartment, it shall be acceptable to limit the ventilation to that provided by drain holes of sufficient size and disposition to prevent clogging and to prevent excessive pressure resulting from altitude changes. If flexible tank liners are installed, the design of the venting arrangement for the spaces between the liner and its container shall take into consideration the need for maintaining proper relationship to tank vent pressures for all expected flight conditions.

(c) Location of fuel tanks shall comply with the provisions of § 7.481 (b).

(d) No portion of rotorcraft skin which lies immediately adjacent to a major air egress opening from the engine compartment shall act as the wall of an integral tank.

(e) Fuel tanks shall be isolated from personnel compartments by means of fumeproof and fuelproof enclosures.

(f) Fuel tanks located in close proximity to personnel compartments, engines, or combustion heaters shall be so designed or protected and installed as to assure that they will retain their contents in accidents of a severity which will produce the deceleration specified in § 7.260.

§ 7.423 *Fuel tank expansion space.* Fuel tanks shall be provided with an expansion space of not less than 2 percent of the tank capacity. It shall not be possible to fill the fuel tank expansion space inadvertently when the rotorcraft is in the normal ground attitude.

§ 7.424 *Fuel tank sump.* (a) Each fuel tank shall be provided with a sump having a capacity of not less than either 0.10 percent of the tank capacity or one-sixteenth of a gallon, whi is greater.

(b) The fuel tank sump capacity specified in paragraph (this section shall be effective with the rotorcraft in all normal and ground attitudes, and shall be located so that the sump contents cannot be drawn out through the tank outlet openin fuel tank shall be constructed to permit drainage of any hazar quantity of water from all portions of the tank to the sump wh the rotorcraft is in the ground attitude.

(c) Fuel tank sumps shall be provided with an accessibl easily operable drain to permit complete drainage of the sump the ground. The drain shall discharge clear of all portions of rotorcraft and shall be provided with means for positive locki the drain in the closed position, either manually or automatica

§ 7.425 *Fuel tank filler connection.* (a) The design of fuel tank filler connections shall be such as to prevent the en of fuel into the fuel tank compartment or to any other portion the rotorcraft other than the tank itself. The fuel tank filler sh marked as prescribed in § 7.738 (b) (1).

(b) Recessed fuel tank filler connections which can retain appreciable quantity of fuel shall incorporate a drain, and the shall discharge clear of all portions of the rotorcraft.

(c) The fuel tank filler cap shall provide a fuel-tight seal under the pressure expected to be encountered in normal ope

(d) *Category A*: Fuel tank filler caps or filler cap covers shall incorporate features which provide a warning indication caps are not fully locked or seated on the filler connection.

§ 7.426 *Fuel tank vents and carburetor vapor vents.* (a) Fuel tanks shall be vented from the top portion of the expansion space in such a manner that venting of the tank is effective under all normal flight conditions. The following sh applicable:

(1) The vents shall be arranged to avoid stoppage by dirt or ice formation.

(2) The vent arrangement shall be constructed to preclude the possibility of siphoning fuel during normal operation.

(3) The venting capacity and vent pressure levels shall be appropriate for the tank installation so as to maintain acceptable differences of pressure between the interior and exterior of the tank during normal flight operation, during maximum rate of ascent and descent, and, if applicable, during refueling and defueling.

(4) Air spaces of tanks with interconnected outlets shall also be interconnected.

(5) There shall be no points in the vent line where moisture could accumulate with the rotorcraft in either the ground or the level flight attitude unless drainage is provided.

(6) Vents and drainage shall not terminate at points where the discharge of fuel from the vent outlet would constitute a fire hazard or from which fumes could enter personnel compartments.

(b) Carburetors which are provided with vapor elimination connections shall be provided with a vent line to lead vapors back to one of the fuel tanks. The vents shall comply with the following:

(1) Provisions shall be incorporated in the vent system to avoid stoppage by ice.

(2) If more than one fuel tank is provided and it is necessary to use the tanks in a definite sequence, the vapor vent return line shall lead back to the fuel tank used for take-off and landing.

§ 7.427 *Fuel tank outlet.* A fuel strainer of 8 to 16 meshes per inch shall be provided either for the fuel tank outlet or for the booster pump. Strainers shall comply with the following:

(a) The clear area of the fuel tank outlet strainer shall not be less than 5 times the area of the fuel tank outlet line.

(b) The diameter of the strainer shall not be less than the diameter of the fuel tank outlet.

(c) Finger strainers shall be accessible for inspection and cleaning.

§ 7.428 *Pressure refueling and fueling provisions below fuel level in the tank.* Fueling connections located below the fuel level in a tank shall be provided with means to prevent the escape of hazardous quantities of fuel from the tank in the event of malfunctioning of the fuel entry valve. For systems intended for pressure refueling, in addition to the normal means provided in the rotorcraft for limiting the tank content, a means shall be installed to prevent damage to the tank in case of failure of the normal means.

FUEL SYSTEM COMPONENTS

§ 7.430 *Fuel pumps* - (a) *Main pumps.* (1) If the engine fuel supply is maintained by means of pumps which are not an integral part of the fuel control system certificated as part of the engine, at least one fuel pump for each engine shall be engine-driven.

(2) All positive displacement fuel pumps shall incorporate an integral by-pass unless provision is made for a continuous supply of fuel to all engines in case of failure of any one pump. Engine fuel injection pumps which are approved as an integral part of the engine need not incorporate a by-pass.

(b) *Emergency pumps.* Emergency fuel pumps shall be available for immediate use in case of failure of any other fuel pump. No manipulation of fuel valves shall be necessary on the part of the crew to make an emergency fuel pump available to the engine which it is normally intended to serve when the fuel system is being operated in the configuration complying with the provisions of § 7.411.

§ 7.431 *Fuel pump installation.* (a) Provision shall be made to maintain the fuel pressure at the inlet to the carburetor within the range of limits established for proper engine operation.

(b) When necessary for the maintenance of the proper fuel delivery pressure, a connection shall be provided to transmit the carburetor air intake static pressure to the proper fuel pump relief valve connection. In such cases, to avoid erroneous fuel pressure readings, the gauge balance lines shall be independently connected to the carburetor inlet pressure.

(c) The installation of fuel pumps having seals or diaphragms which may be susceptible to leakage shall incorporate provisions for draining away leaking fuel. Drain lines shall terminate at points where discharge of fuel will not create a fire hazard.

§ 7.432 *Fuel system lines and fittings.* (a) Fuel lines shall be installed and supported to prevent excessive vibration and to withstand loads due to fuel pressure, valve actuation, and accelerated flight conditions.

(b) Fuel lines which are connected to components of the rotorcraft between which relative motion could exist shall incorporate provisions for flexibility.

(c) Flexible connections in fuel lines which may be under pressure or subjected to axial loading shall employ flexible hose assemblies rather than hose clamp connections.

(d) Flexible hose shall be of an approved type suitable for the application.

(e) Flexible hoses which might be adversely affected by exposure to high temperatures shall not be employed in locations where excessive temperatures will exist during operation or after engine shutdown.

§ 7.433 *Fuel lines and fittings in designated fire zones.* Fuel lines and fittings in all designated fire zones (see § 7.480) shall comply with the provisions of § 7.483.

§ 7.434 *Fuel valves.* In addition to the requirements of § 7.482 for shutoff means, all fuel valves shall be provided with positive stops or suitable index provisions in the "on" and "off" positions, and they shall be supported so that loads resulting from their operation or from accelerated flight conditions are not transmitted to the lines attached to the valve.

§ 7.435 *Fuel strainer.* (a) A strainer incorporating a sediment trap and drain shall be provided in the fuel system between the fuel tanks and the engine and shall be installed in an accessible location.

(b) The strainer shall provide the necessary degree of protection for the fuel pumps, fuel controls, and the engine against dirt, sediment, and other foreign matter which might be present in the fuel. The screen or straining element shall be able to be easily cleaned.

(c) The strainer shall be mounted in a manner not to cause its weight to be supported by the connecting line or by the inlet or outlet connections of the strainer itself.

§ 7.436 *Fuel system drains.* Complete drainage of the system shall be accomplished by fuel strainer drains and other drains as provided in § 7.424 with the rotorcraft in its normal ground attitude. The following shall apply:

(a) Drains shall discharge clear of all portions of the rotorcraft and shall incorporate means for positive locking of the drain in the closed position, either manually or automatically.

(b) All fuel system drains shall be accessible.

(c) If drainage of the fuel strainer permits compliance with paragraphs (a) and (b) of this section, no additional drains need be provided unless it is possible for a hazardous quantity of water or sediment to be trapped therein. (See also § 7.483 (c).)

§ 7.437 *Fuel quantity indicator.* The fuel quantity indicators (see §§ 7.604 (e) and 7.613 (b)) shall be installed to clearly indicate to the flight crew the quantity of fuel in each tank in flight. When two or more tanks are closely interconnected by a gravity feed system and vented, and it is impossible to feed from each tank separately, only one fuel quantity indicator need be installed.

§ 7.438 *Low fuel warning device.* On rotorcraft with more than one fuel tank there shall be installed in addition to fuel quantity indicators (see § 7.604), warning devices to indicat when the fuel in any tank becomes low.

NOTE: The fuel in any tank is considered to be low when there remains approximately a five-minute usable fuel supply the rotorcraft in the most critical sustained flight attitude.

OIL SYSTEM

§ 7.440 *General.* (a) Each engine shall be provided wit independent oil system capable of supplying the engine with appropriate quantity of oil at a temperature not exceeding the maximum which has been established as safe for continuous operation. The oil system for components of the rotor drive system which require continuous lubrication shall be indepen of the lubrication systems of the engines to whatever extent i necessary to assure the ability to operate with any engine inoperative and to assure the ability to autorotate safely. (Fo system instruments see §§ 7.604 and 7.735.)

(b) The usable oil capacity shall not be less than the pro of the endurance of the rotorcraft under critical operating conditions and the maximum permissible oil consumption of t engine under the same conditions to which product a suitable margin shall be added to assure adequate circulation and coo the oil system. In lieu of a rational analysis of rotorcraft endu and oil consumption, the total usable oil capacity of 1 gallon each 40 gallons of usable fuel capacity, by volume, shall be considered acceptable for reciprocating engine installations.

(c) Oil-fuel ratios lower than those prescribed in paragraph (b) of this section shall be acceptable if substantiated by data the actual oil consumption of the engine.

(d) The ability of the engine and rotor drive system oil cooling provisions to maintain the oil temperature at or below maximum established value shall be demonstrated in accordance with pertinent provisions of §§ 7.450 through 7.455.

§ 7.441 *Oil tank construction.* the following requirements shall apply to the construction of the oil tank:

(a) *Oil tank expansion space.* (1) Oil tanks shall have an expansion space of not less than either 10 percent of the tank capacity or 0.5 gallon, whichever is greater.

(2) Reserve oil tanks which have no direct connection to any engine shall have an expansion space which is not less than 2 percent of the tank capacity.

(3) It shall not be possible to fill the oil tank expansion space inadvertently when the rotorcraft is in the normal ground attitude.

(b) *Oil tank filler connection.* (1) Recessed oil tank filler connections which can retain any appreciable quantity of oil shall incorporate a drain, and the drain shall discharge clear of all portions of the rotorcraft.

(2) The oil tank filler cap shall provide an oil-tight seal under the pressure expected to be encountered in operation.

(3) Category A: Oil tank filler caps or filler cap covers shall incorporate features which provide a warning indication when caps are not fully locked or seated on the filler connection.

(4) The oil filler shall be marked as prescribed in § 7.738 (b) (2).

(c) *Oil tank vent.* (1) Oil tanks shall be vented from the top portion of the expansion space in such a manner that venting of the tank is effective under all normal flight conditions.

(2) Oil tank vents shall be arranged so that condensation of water vapor which might freeze and obstruct the line cannot accumulate at any point. (See also § 7.483 (c).)

(d) *Oil tank outlet.* Provision shall be made either to prevent entrance into the tank itself or into the tank outlet of any foreign object which might obstruct the flow of oil through the system. The oil tank outlet shall not be enclosed by any screen or guard which would reduce the flow of oil below a safe value at any operating temperature condition.

(e) *Flexible oil tank liners.* Flexible oil tank liners shall be of an approved type or shall be shown to be suitable for the particular application.

§ 7.442 *Oil tank tests.* (a) Oil tanks shall be capable of withstanding without failure all vibration, inertia, and fluid loads to which they would be subjected in operation.

(b) The provisions of § 7.421 shall be applicable to oil tanks, except that the test pressure specified in § 7.421 (a) shall be 5 psi.

§ 7.443 *Oil tank installation.* The oil tank installation shall comply with the provisions of § 7.422, except that the location of an engine oil tank in a designated fire zone shall be acceptable if the tank and its supports are of fireproof construction to the extent that damage by fire to any nonfireproof parts would not result in leakage or spillage of oil.

§ 7.444 *Oil lines and fittings*—(a) *General.* The provisions of § 7.432 shall be applicable to oil lines.

(b) *Lines and fittings in designated fire zones.* Oil lines and fittings in all designated fire zones (see § 7.480) shall comply with the provisions of § 7.483.

(c) *Breather lines.* (1) Breather lines shall be arranged so that condensation of water vapor which might freeze and obstruct the line cannot accumulate at any point.

(2) Breathers shall discharge in a location which will not constitute a fire hazard in case foaming occurs and in a manner so that the emitted oil will not impinge upon the pilots' windshield.

(3) The breather shall not discharge into the engine air induction system. (See also § 7.483 (c).)

§ 7.445 *Oil valves.* (a) The requirements of § 7.482 for shutoff means shall be complied with. Closing of oil shutoff means shall not prevent autorotation of the rotors.

(b) All oil valves shall be provided with positive stops or suitable index provisions in the "on" and "off" positions, and they shall be supported so that loads resulting from their operation or from accelerated flight conditions are not transmitted to the lines attached to the valves.

§ 7.446 *Oil radiators.* (a) Oil radiators shall be capable of withstanding without failure all vibration, inertia, and oil pressure loads to which they would be subjected in operation.

(b) Oil radiator air ducts shall be located or so equipped that, in case of fire, flames cannot impinge directly upon the radiator with the air flow as it would exist either with the engine operating or inoperative.

§ 7.447 *Oil filters.* If the rotorcraft is equipped with an oil filter, the filter shall be constructed or installed in such a manner that complete blocking of the flow through the filter element will not prevent the safe operation of the engine or rotor drive oil supply systems.

§ 7.448 *Oil system drains.* Accessible drains shall be provided to permit safe drainage of the entire oil system and shall incorporate means for the positive locking of the drain in the closed position, either manually or automatically. (See also § 7.483 (c).)

COOLING SYSTEM

§ 7.450 *General.* The powerplant cooling provisions shall be capable of maintaining the temperatures of all powerplant components, engine fluids, and the carburetor intake air within safe values under all conditions of ground and flight operation. Cooling provisions shall also be provided to maintain the fluids in any power transmission within safe values under conditions of ground and flight operations. (For cooling system instruments see §§ 7.604 and 7.734.)

§ 7.451 *Cooling tests*—(a) *General.* Compliance with the provisions of § 7.450 shall be demonstrated by flight tests in which the temperatures of selected powerplant components, engine(s), and transmission fluids are obtained under critical ground, water, and flight operating conditions. If the tests are conducted under conditions which deviate from the maximum anticipated air temperature (see paragraph (b) of this section), the recorded powerplant temperatures shall be corrected in accordance with the provisions of paragraphs (c) and (d) of this section. The corrected temperatures determined in this manner shall not exceed the maximum established safe values. The fuel used during the cooling tests shall be of the minimum octane number approved for the engine(s) involved, and the mixture settings shall be those used in normal operation. The test procedures shall be as outlined in §§ 7.452 through 7.455.

(b) *Maximum anticipated air temperature.* The maximum anticipated air temperature (hot-day condition) shall be 100°F. at sea level, decreasing from this value at the rate of 3.6°F. per thousand feet of altitude above sea level until a temperature of -67°F. is reached above which altitude the temperature shall be constant at -67°F.

(c) *Correction factor for cylinder head, oil inlet, carburetor air, and engine and transmission coolant outlet temperatures.* The cylinder head, oil inlet, carburetor air, and engine coolant outlet temperatures shall be corrected by adding the difference between the maximum anticipated air temperature and the temperature of the ambient air at the time of the first occurrence of maximum head, oil, air, or coolant temperature recorded during the cooling test, unless a more rational correction is shown to be applicable.

(d) *Correction factor for cylinder barrel temperatures.* Cylinder barrel temperatures shall be corrected by adding 0.7 of the difference between the maximum anticipated air 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, unless a more rational correction is shown to be applicable.

§ 7.452 *Climb cooling test procedure.* Climb cooling tests shall be conducted on all Category A rotorcraft in accor with paragraphs (a) through (d) of this section. Such tests sh conducted on all multiengine Category B rotorcraft that are certificated in accordance with the Transport Category A pow plant installation requirements as well as with § 7.384 (a) at th steady rate of climb or descent established in accordance wit 7.115(b)(2).

(a) The climb or descent cooling test shall be conducte the engine inoperative which produces the most adverse coo conditions for the engine(s) and powerplant components rem in operation.

(b) All remaining engine(s) shall be operated at their maximum continuous power or at full throttle when above the critical altitude.

(c) After stabilizing temperatures in flight the climb shall b started at or below the lower of the altitudes specified in subparagraphs (1) and (2) of this paragraph and shall be cont until at least 5 minutes after the occurrence of the highest temperature recorded, or until the maximum altitude is reache which certification is desired. For Category B rotorcraft whic not have a positive rate of climb, the descent shall start at the engine-critical altitude and terminate at the higher of the altitu specified in subparagraphs (3) and (4) of this paragraph:

(1) 1,000 feet below the engine critical altitude,

(2) 1,000 feet below the maximum altitude at which the r of climb is equal to 150 fpm,

(3) The altitude at which level flight can be maintained one engine operative, or

(4) Sea level.

(d) The climb or descent shall be conducted at an air sp selected to represent a normal operational practice for the configuration being tested. However, if it is determined that characteristics of the cooling provisions make them sensitive rotorcraft speed, the most critical air speed shall be used, but need not exceed the speeds established in accordance with § 7.115 (a)(2) or (b)(2). It shall be acceptable to conduct the climb cooling test in conjunction with the take-off cooling test of § 7.453.

§ 7.453 *Category A; take-off cooling test procedure.* A take-off cooling test shall be conducted to demonstrate cooling during take-off and during subsequent climb with one engine inoperative. The following procedure shall be applicable:

(a) The take-off cooling test shall be commenced by stabilizing temperatures while hovering in ground effect with all engines operating at necessary power, with the appropriate cowl flap and shutter settings, and at the maximum weight for which certification is sought.

(b) After all temperatures have stabilized, the climb shall be started at the lowest practicable altitude and shall be conducted with one engine inoperative.

(c) The remaining engines shall be operated at take-off rpm and power (or at full throttle when above the take-off critical altitude) for the same time interval as take-off power is used during determination of the take-off flight path (see § 7.114 (a)).

(d) At the end of the time interval prescribed in paragraph (c) of this section the power shall be reduced to the maximum continuous power and the climb continued until at least 5 minutes after the occurrence of the highest temperature recorded.

(e) The speeds shall be those used during determination of the take-off flight path (see § 7.114 (a)).

§ 7.454 *Category B; cooling test procedure.* Cooling tests shall be conducted on all Category B rotorcraft in accordance with paragraphs (a) through (e) of this section (see § 7.452 for climb cooling tests where applicable).

(a) The cooling test shall be commenced by stabilizing temperatures while hovering in ground effect with necessary power and appropriate cowl flaps and shutter settings and at the maximum weight for which certification is sought.

(b) After all temperatures have stabilized, the climb shall be started at the lowest practicable altitude with take-off power.

(c) Take-off power shall be used for the same time interval as take-off power is used during determination of the take-off flight path (see § 7.114 (b)).

(d) At the end of the time interval prescribed in paragraph (c) of this section the power shall be reduced to the maximum continuous power and the climb continued until at least 5 minutes after the occurrence of the highest temperature recorded.

(e) The cooling test shall be conducted at an air speed corresponding to normal operational practice for the configuration being tested. However, if it is determined that characteristics of the cooling provisions make them sensitive to rotorcraft speed, the most critical air speed shall be used, but need not exceed the best rate-of-climb speed with maximum continuous power.

§ 7.455 *Hovering cooling test procedures.* Hovering cooling tests shall be conducted as follows:

(a) At maximum certificated weight or at the highest weight at which the rotorcraft is capable of hovering, if less than maximum certificated weight, at sea level using the power required to hover but not exceeding maximum continuous power, in the ground effect with still wind until at least 5 minutes after the occurrence of the highest temperature recorded.

(b) With all engines operating at maximum continuous power, the rotorcraft at maximum certificated weight, and the altitude resulting in zero rate of climb for this configuration until at least five minutes after the occurrence of the highest temperature recorded.

INDUCTION AND EXHAUST SYSTEMS

§ 7.460 *General.* (a) The engine air induction system shall permit supplying the proper quantity of air to the engine under all conditions of operation.

(b) The induction system shall provide air for proper fuel metering and mixture distribution with the induction system valves in any position.

(c) Air intake shall not open either within the engine accessory section or other areas of the powerplant compartment where emergence of backfire flame would constitute a fire hazard.

(d) Each engine shall be provided with an alternate air source.

(e) Alternate air intakes shall be so located as to preclude the entrance of rain, ice, or any other foreign matter.

§ 7.461 *Induction system de-icing and anti-icing provisions*—(a) *General.* The engine air induction system shall incorporate means for the prevention and elimination of ice accumulations.

(b) *Heat rise.* Unless it is demonstrated that other means will accomplish the intent of paragraph (a) of this section, compliance with the following heat-rise provisions shall be demonstrated in air free of visible moisture at a temperature of 30°F.:

(1) Rotorcraft equipped with sea level engines employing conventional venturi carburetors shall have a preheater capable of providing a heat rise of 90°F. when the engines are operating at 60 percent of their maximum continuous power.

(2) Rotorcraft equipped with sea level engines employing carburetors which embody features tending to reduce the possibility of ice formation shall have a preheater capable of providing a heat rise of 70°F. when the engines are operating at 60 percent of their maximum continuous power.

(3) Rotorcraft equipped with altitude engines employing conventional venturi carburetors shall have a preheater capable of providing a heat rise of 120°F. when the engines are operating at 60 percent of their maximum continuous power.

(4) Rotorcraft equipped with altitude engines employing carburetors which embody features tending to reduce the possibility of ice formation shall have a preheater capable of providing a heat rise of 100°F. when the engines are operating at 60 percent of their maximum continuous power.

§ 7.462 *Carburetor air preheater design.* Carburetor air preheater shall incorporate the following provisions:

(a) Means shall be provided to assure ventilation of the preheater when the engine is being operated with cold air.

(b) The preheater shall be constructed to permit inspection of exhaust manifold parts which it surrounds and also to permit inspection of critical portions of the preheater itself.

§ 7.463 *Induction system ducts.* Induction system ducts shall incorporate the following provisions:

(a) Induction system ducts ahead of the first stage of the supercharger shall be provided with drains to prevent hazardous accumulations of fuel and moisture in the ground attitude. The drains shall not discharge in locations which might cause a fire hazard.

(b) Sufficient strength shall be incorporated in the ducts to prevent induction system failures resulting from normal backfire conditions.

(c) Ducts which are connected to components of the rotorcraft between which relative motion could exist shall incorporate provisions for flexibility.

(d) Induction system ducts within any fire zone for which a fire-extinguishing system is required shall be of fire-resistant construction.

NOTE: Fireproof ducts are required in instances in which the duct may pass through a fire wall.

§ 7.464 *Induction system screens.* If induction system screens are employed, they shall comply with the following provisions:

(a) Screens shall be located upstream from the carburet

(b) Screens shall not be located in portions of the induc system which constitute the only passage through which air reach the engine, unless the screen is so located that it can b by heated air.

(c) De-icing of induction system screens by means of a alone in lieu of heated air shall not be acceptable.

(d) It shall not be possible for fuel to impinge upon the screens.

§ 7.465 *Carburetor air cooling.* Installations employin two-stage superchargers shall be provided with means to mai the air temperature at the inlet to the carburetor at or below th maximum established value. Demonstration of compliance wi this provisions shall be accomplished in accordance with § 7.

§ 7.466 *Inter-coolers and after-coolers.* Inter-coolers and after-coolers shall be capable of withstanding without fai vibration, inertia, and air pressure loads to which they would subjected in operation.

§ 7.467 *Exhaust system and installation components*—(a) *General.* (1) The exhaust system shall be constructed and arranged to assure the safe disposal of exha gases without the existence of a fire hazard or carbon monoxi contamination of air in personnel compartments.

(2) Unless appropriate precautions are taken, exhaust system parts shall not be located in hazardous proximity to portions of any system carrying flammable fluids or vapors n shall they be located under portions of such systems where t latter could be subject to leakage.

(3) All rotorcraft components upon which hot exhaust g might impinge, or which could be subjected to high temperatu due to proximity to

exhaust system parts, shall be constructed of fireproof material. All exhaust system components shall be separated by means of fireproof shields from adjacent portions of the rotorcraft which are outside the engine compartment.

(4) Exhaust gases shall not discharge in a manner to cause a fire hazard with respect to any flammable fluid vent or drain.

(5) Exhaust gases shall not discharge at a location which will cause a glare seriously affecting pilot visibility at night.

(6) All exhaust system components shall be ventilated to prevent the existence of points of excessively high temperature.

(7) Exhaust shrouds shall be ventilated or insulated to avoid during normal operation a temperature sufficiently high to ignite any flammable fluids or vapors external to the shrouds.

(b) *Exhaust piping.* (1) Exhaust piping shall be constructed of material resistant to heat and corrosion, and shall incorporate provisions to prevent failure due to expansion when heated to operating temperatures.

(2) Exhaust pipes shall be supported to withstand all vibration and inertia loads to which they would be subjected in operation.

(3) Portions of the exhaust piping which are connected to components between which relative motion could exist shall incorporate provisions for flexibility.

(c) *Exhaust heat exchangers.* (1) Exhaust heat exchangers shall be constructed and installed to assure their ability to withstand without failure all vibration, inertia, and other loads to which they would be subjected in operation.

(2) Exhaust heat exchangers shall be constructed of materials which are suitable for continued operation at high temperatures and which are resistant to corrosion due to elements contained in exhaust gases.

(3) Provision shall be made for the inspection of all critical portions of exhaust heat exchangers.

(4) Exhaust heat exchangers shall incorporate cooling provisions wherever they are subject to contact with exhaust gases.

(5) Exhaust heat exchangers or muffs shall incorporate no stagnant areas or liquid traps which would increase the possibility of ignition of flammable fluids or vapors which might be present in case of failure or malfunctioning of components carrying flammable fluids.

(d) *Exhaust heating of ventilating air.* If an exhaust heat exchanger is used for heating ventilating air used by personnel, a secondary heat exchanger shall be provided between the primary exhaust gas heat exchanger and the ventilating air system, unless it is demonstrated that other means used preclude harmful contamination of the ventilating air.

POWERPLANT CONTROLS AND ACCESSORIES

§ 7.470 *Powerplant controls; general.* The provisions of § 7.353 shall be applicable to all powerplant controls with respect to location and arrangement, and the provisions of § 7.737 shall be applicable to all powerplant controls with respect to marking. All flexible powerplant controls shall be of an approved type. In addition, all powerplant controls shall comply with the following:

(a) Controls shall be so located that they cannot be inadvertently operated by personnel entering, leaving, or making normal movements in the cockpit.

(b) Controls shall maintain any set position without constant attention by flight personnel. They shall not creep due to control loads or vibration.

(c) Controls shall have strength and rigidity to withstand operating loads without failure and without excessive deflection.

§ 7.471 *Throttle and A.D.I. system controls.* (a) A separate throttle control shall be provided for each engine. Throttle controls shall be grouped and arranged to permit separate control of each engine and also simultaneous control of all engines in such a manner that proper synchronization of the power of all engines can be readily achieved.

(b) Throttle controls shall afford a positive and immediately responsive means of controlling the engines.

(c) If an antidetonant injection system is provided, the control shall be incorporated in the throttle controls, except that a separate control may be provided for the antidetonant injection pump.

§ 7.472 *Ignition switches.* Ignition switches shall provide control for each ignition circuit on each engine. Means shall be provided for quickly shutting off all ignition by the grouping of switches or by providing a master ignition control. If a master ignition control is provided, a guard shall be incorporated to prevent inadvertent operation of the control.

§ 7.473 *Mixture controls.* (a) If mixture controls are provided, a separate control shall be provided for each engine. The mixture controls shall be grouped and arranged to permit separate control of each engine and also simultaneous control of all engines.

(b) Any intermediate position of the mixture controls which corresponds with a normal operating setting shall be provided with a means of identification by feel and by vision.

§ 7.474 *Carburetor air preheat controls.* Separate carburetor air preheat controls shall be provided to regulate the temperature of the carburetor air for each engine.

§ 7.475 *Supercharger controls.* Supercharger controls shall be accessible to the pilots, except where a separate flight engineer station with a control panel is provided, in which case they shall be accessible to the flight engineer.

§ 7.476 *Rotor brake controls.* It shall be physically impossible to apply inadvertently the rotor brake in flight. A means shall be provided to warn the crew if the rotor brake has not been completely released prior to take-off.

§ 7.477 *Powerplant accessories.* (a) Engine mounted accessories shall be of a type approved for installation on the engine involved, and shall utilize the provisions made on the engine for mounting.

(b) Items of electrical equipment subject to arcing or sparking shall be installed in such a way as to minimize the possibility of their igniting flammable fluids or vapors which might be present.

(c) If continued rotation of an engine-driven cabin supercharger or any remote accessory driven by the engine will constitute a hazard in case malfunctioning occurs, means shall be provided to prevent hazardous rotation of such accessory without interfering with the continued operation of the engine. (See also § 7.358(c).)

NOTE: Hazardous rotation may involve consideration of mechanical damage or sustained air flows which may be dangerous under certain conditions.

§ 7.478 *Engine ignition systems.* (a) Battery ignition systems shall be supplemented with a generator which is automatically made available as an alternate source of electrical energy to permit continued engine operation in the event of the depletion of any battery.

(b) The capacity of batteries and generators shall be sufficient to meet the simultaneous demands of the engine ignition system and the greatest demands of any rotorcraft electrical system components which draw electrical energy from the same source.

(1) The design of the engine ignition system shall take into consideration the condition of an inoperative generator and the condition of a completely depleted battery when the generator is running at its normal operating speed.

(2) If only one batter is provided, the design of the engine ignition system shall take into consideration the condition in which the battery is completely depleted and the generator is operat idling speed.

(3) Portions of magneto ground wires for separate igniti circuits which lie on the engine side of the fire wall shall be installed, located, or protected so as to minimize the possibili simultaneous failure of two or more wires as a result of mecha damage, electrical faults, etc.

(4) Ground wires for any engine shall not be routed thro fire zones, except those associated with the engine which the serve, unless those portions of the wires which are located ir fire zones are fireproof or are protected against the possibility damage by fire in a manner to render them fireproof. (See § 7. for ignition switches.)

(5) Ignition circuits shall be electrically independent of a other electrical circuits except circuits used for analyzing the operation of the ignition system.

(c) Means shall be provided to warn flight personnel if malfunctioning of any part of the electrical system is causing continuous discharging of a battery which is necessary for en ignition. (See § 7.472 for ignition switches.)

Powerplant Fire Protection

§ 7.480 *Designated fire zones.* (a) Designated fire zones shall comprise the following regions: (See also § 7.385.)

(1) Engine power section.

(2) Engine accessory section.

(3) Complete powerplant compartments in which no isolation is provided between the engine power section and t engine accessory section.

(4) Auxiliary power unit compartments, and

(5) Fuel-burning heaters and other combustion equipme installations as defined by § 7.383.

(b) Designated fire zones shall be protected from fire by compliance with §§ 7.481 through 7.489.

NOTE: For Category B rotorcraft, the powerplant fire protection provisions are intended to insure that the main and auxiliary rotors and controls remain operable, that the essential rotorcraft structure remains intact, and that the passengers and crew are otherwise protected for a period of at least 5 minutes after the start of an engine fire to permit a controlled autorotative landing.

§ 7.481 *Flammable fluids.* (a) No tanks or reservoirs which are a part of a system containing flammable fluids or gases shall be located in designated fire zones, except where the fluid contained, the design of the system, the materials used in the tank and its supports, the shutoff means, all connections, lines, and controls are such as to provide an equally high degree of safety.

(b) Fuel tanks shall be isolated from the engines by a fire wall or shroud. Not less than one-half inch of clear airspace shall be provided between any tank or reservoir and a fire wall or shroud isolating a designated fire zone, unless other equivalent means are used to protect against heat transfer from the fire zone to the flammable fluid.

(c) If absorbent materials are located in proximity to flammable fluid system components which might be subject to leakage, such materials shall be covered or treated to prevent the absorption of hazardous quantities of fluids.

§ 7.482 *Shutoff means.* (a) Means shall be provided for shutting off or otherwise preventing hazardous quantities of fuel, oil, de-icer, and other flammable fluids from flowing into, within, or through any designated fire zone specified in § 7.480(a), except that means need not be provided to shut off flow in lines forming an integral part of an engine. Closing any fuel shutoff valve for any engine shall not affect more than the selected engine.

(1) *Category A.* It shall be shown that no hazardous quantity of flammable fluid could drain into any designated fire zone after shutting off has been accomplished. Closing the fuel shutoff valve for any engine shall not make any of the fuel supply unavailable to the remaining engines.

(2) *Category B.* In installation using engines of less than 500 cubic inches displacement, shutoff means need not be provided for engine oil systems.

(b) Operation of the shutoff means shall not interfere with the subsequent emergency operation of other equipment, such as declutching the engine from the rotor drive.

(c) The shutoff means shall be located outside of designated fire zones, unless an equally high degree of safety is otherwise provided (see § 7.481).

(d) Provision shall be made to guard against inadvertent operation of the shutoff means, and to make it possible for the crew to reopen the shutoff means in flight after it has once been closed.

§ 7.483 *Lines and fittings.* All lines and fittings carrying flammable fluids or gases in areas subject to engine fire conditions shall comply with the provisions of paragraphs (a) through (c) of this section.

(a) Lines and fittings which are under pressure, or which attach directly to the engine, or which are subject to relative motion between components shall be flexible, fire-resistant lines with fire-resistant end fittings of the permanently attached, detachable, or other approved types. The provisions of this paragraph shall not apply to those lines and fittings which form an integral part of the engine.

(b) Lines and fittings which are not subject to pressure or to relative motion between components shall be of fire-resistant materials.

(c) Vent and drain lines and fittings shall be subject to the provisions of paragraphs (a) and (b) of this section unless a failure of such line or fitting will not result in, or add to, a fire hazard.

§ 7.484 *Fire-extinguishing systems* — (a) *General.* (1) Fire-extinguishing systems shall be provided to serve all designated fire zones except that such systems need not be provided on Category B rotorcraft employing engines of 1,500 cubic inches or less displacement.

(2) On multiengine rotorcraft, the fire-extinguishing system, the quantity of extinguishing agent, and the rate of discharge shall be such as to provide two adequate discharges. It shall be possible to direct both discharges to any main engine installation. Individual "one-shot" systems shall be acceptable in the case of auxiliary power units, fuel-burning heaters, and other combustion equipment. On single-engine rotorcraft, the quantity of extinguishing agent and the rate of discharge shall be such as to provide one adequate discharge for the engine compartment.

(3) The fire-extinguishing system for a powerplant shall be capable of protecting simultaneously all zones of the powerplant compartment for which protection is provided.

(b) *Fire-extinguishing agents.* (1) Extinguishing agents employed shall be methyl bromide, carbon dioxide, or any other agent which has been shown to provide equivalent extinguishing action.

(2) If methyl bromide, carbon dioxide, or any other toxic extinguishing agent is employed, provision shall be made to prevent the entrance of harmful concentrations of fluid or fluid vapors into any personnel compartment either due to leakage during normal operation of the rotorcraft or as a result of discharging the fire extinguisher on the ground or in flight even though a defect may exist in the extinguishing system. Compliance with this requirement shall be demonstrated by appropriate tests.

(3) If a methyl bromide system is provided, the containers shall be charged with a dry agent and shall be sealed by the fire extinguisher manufacturer or by any other part employing appropriate recharging equipment.

(c) *Extinguishing agent container pressure relief.* Extinguishing agent containers shall be provided with a pressure relief to prevent bursting of the container due to excessive internal pressures. The following provisions shall apply:

(1) The discharge line from the relief connection shall terminate outside the rotorcraft in a location convenient for inspection on the ground.

(2) An indicator shall be provided at the discharge end of the line to provide a visual indication when the container has discharged.

(d) *Extinguishing agent container compartment temperature.* Under all conditions in which the rotorcraft is intended for operation, the temperature range of the extinguishing agent containers shall be maintained to assure that the pressure in the containers can neither fall below the minimum necessary to provide an adequate rate of extinguishing agent discharge nor rise above a safe limit so that the system will not be prematurely discharged.

(e) *Fire-extinguishing system materials.* Materials in the fire-extinguishing system shall not react chemically with the extinguishing agent so as to constitute a hazard. All components of the fire-extinguishing systems located in engine compartments shall be constructed of fireproof materials.

§ 7.485 *Fire-detector system.* Quick-acting fire detectors of an approved type shall be provided in all designated fire zones, except on Category B rotorcraft employing engines of 900 cubic inches or less displacement. The fire detectors shall be sufficient in number and location to assure prompt detection of fire in such zones. Fire detectors shall comply with the following provisions:

(a) Fire detectors shall be constructed and installed to assure their ability to resist without failure all vibration, inertia, and other loads to which they would be subjected in operation.

(b) Fire detectors shall be unaffected by exposure to oil, water, or other fluids or fumes which might be present.

(c) Means shall be provided to permit the crew to check flight the functioning of the electrical circuit associated with t fire-detector system.

(d) Wiring and other components of the fire-detector systems which are located in engine compartments shall be of resistant construction.

(e) Detector system components for any fire zone shall pass through other fire zones, unless they are protected agai possibility of false warnings resulting from fires in zones thro which they pass. This requirement shall not be applicable wi respect to zones which are simultaneously protected by the sa detector and extinguishing systems.

§ 7.486 *Fire walls.* Engines shall be isolated from personnel compartments by means of fire walls, shrouds, or o equivalent means. They shall be similarly isolated from the structure, controls, rotor mechanism, and other parts essentia controlled flight and landing of the rotorcraft, unless such pa protected in accordance with the provisions of § 7.384. All auxiliary power units, fuel-burning heaters, and other combus equipment which are intended for operation in flight shall be isolated from the remainder of the rotorcraft by means of fire w shrouds, or other equivalent means. In complying with the provisions of this section, account shall be taken of the proba path of a fire as affected by the air flow in normal flight and in autorotation. The following shall apply:

(a) Fire walls and shrouds shall be constructed in such manner that no hazardous quantity of air, fluids, or flame can from the engine compartment to other portions of the rotorcra

(b) All openings in the firewall or shroud shall be sealed with close-fitting fireproof grommets, bushings, or firewall fit

(c) Fire walls and shrouds shall be constructed of firepr material and shall be protected against corrosion.

§ 7.487 *Cowling.* (a) Cowling or engine compartment covering shall be constructed and supported so as to make it capable of resisting all vibration, inertia, and air loads to which it would be subjected in operation.

(b) Cowling shall have drainage and ventilation provisions as prescribed in § 7.489.

(c) On rotorcraft equipped with a diaphragm complying with § 7.488, the parts of the accessory section cowling which might be subject to flame in the event of a fire in the engine power section of the powerplant shall be constructed of fireproof material and shall comply with the provisions of § 7.486.

(d) Those portions of the cowling or engine compartment covering which would be subjected to high temperatures due to their proximity to exhaust system parts or exhaust gas impingement shall be constructed of fireproof material.

(e) Category A: The rotorcraft shall be so designed and constructed that fire originating in any fire zone cannot enter, either through openings or by burning through external skin, into any other zone or region where such fire would create additional hazards. If the rotorcraft is provided with a retractable landing gear, this provision shall apply with the landing gear retracted. Fireproof materials shall be used for all skin areas which might be subjected to flame in the event of a fire originating in the engine power or accessory sections.

§ 7.488 *Category A; engine accessory section diaphragm.* Unless equivalent protection can be shown by other means, a diaphragm shall be provided on air-cooled engines to isolate the engine power section and all portions of the exhaust system from the engine accessory compartment. This diaphragm shall comply with the provisions of § 7.486.

§ 7.489 *Drainage and ventilation of fire zones.* (a) Complete drainage of all portions of designated fire zones shall be provided to minimize the hazards resulting from failure or malfunctioning of components containing flammable fluids. The drainage provisions shall be effective under conditions expected to prevail when drainage is needed and shall be so arranged that the discharged fluid will not cause an additional fire hazard.

(b) All designated fire zones shall be ventilated to prevent the accumulation of flammable vapors. Ventilation openings shall not be placed in locations which would permit the entrance of flammable fluids, vapors, or flame from other zones. The ventilation provisions shall be so arranged that the discharged vapors will not cause an additional fire hazard.

(c) Category A: Except with respect to the engine power section of the power-plant compartment, provision shall be made to permit the crew to shut off sources of forced ventilation in any fire zone, unless the amount of extinguishing agent and rate of discharge are based on maximum air flow through the zone.

SUBPART F—EQUIPMENT

GENERAL

§ 7.600 *Scope.* The required basic equipment as prescribed in this subpart is the minimum which shall be installed in the rotorcraft for certification. Such additional equipment as is necessary for a specific type of operation is prescribed in the operating rules of the regulations in this subchapter.

§ 7.601 *Functional and installational requirements.* Each item of equipment installed in a rotorcraft shall be:

(a) Of a type design appropriate to perform its intended function;

(b) Labeled as to its identification, function, or operational limitations, or any combination of these, whichever is applicable;

(c) Installed in accordance with specified limitations of the equipment; and

(d) Demonstrated to function properly in the rotorcraft.

§ 7.602 *Required basic equipment.* The equipment listed in §§ 7.603 through 7.605 shall be the required basic equipment. (See § 7.600.)

§ 7.603 *Flight and navigational instruments.* (See § 7.612 for installation requirements.)

(a) Air-speed indicating system.

(b) Altimeter (sensitive).

(c) Clock (sweep-second).

(d) Free-air temperature indicator.

(e) Gyroscopic bank and pitch indicator (non-tumbling type).

(f) Gyroscopic rate-of-turn indicator (with bank indicator).

(g) Gyroscopic direction indicator.

(h) Magnetic direction indicator.

(i) Rate-of-climb indicator (vertical speed).

§ 7.604 *Powerplant instruments.* (See § 7.613 for installation requirements.)

(a) Carburetor air temperature indictor for each engine.

(b) Cylinder head temperature indicator for each air-cooled engine, or coolant temperature indicator for each liquid-cooled engine.

(c) Category A: An individual fuel pressure indicator for each engine and either an independent warning device for each engine or a master warning device for all engines with means for isolating the individual warning circuit from the master warning device.

(d) Category B: An individual fuel pressure indicator for each engine.

(e) Fuel quantity indicator for each fuel tank. (See § 7.437.)

(f) Low fuel warning device for each tank if a multi-tank system is employed. (See § 7.416.)

(g) Manifold pressure indicator for each engine, if altitude engines are used.

(h) Category A: An individual oil pressure indicator for each engine and either an independent warning device for each engine or a master warning device for all engines with means for isolating the individual warning circuit from the master warning device.

(i) Category B: An individual oil pressure indictor for each engine.

(j) Oil pressure warning device for each pressure-lubricated gear box to indicate when the oil pressure falls below a safe value.

(k) Oil quantity indicator for each oil tank and each rotor drive gear box, if lubricant is self-contained. (See § 7.613 (d).)

(l) Oil temperature indicator for each engine.

(m) Oil temperature warning device to indicate when the oil temperature in any rotor drive gear box exceeds a safe value.

(n) Tachometer for each engine. (These tachometers may be combined in a single instrument with that required by paragraph (o) of this section, except that such an instrument shall indicate rotor rpm during autorotation.)

(o) Tachometer(s) to indicate rotor rpm of the main rotor(s), or for each main rotor, the speed of which can vary appreciably with respect to another main rotor.

(p) Category A: Fire warning indicators. (See § 7.485.)

(q) Category B: Fire warning indicators when fire detection is required. (See § 7.485.)

§ 7.605 *Miscellaneous equipment.* There shall be installed:

(a) Approved seats for all occupants. (See § 7.355.)

(b) Approved individual safety belts for all occupants. (See § 7.643.)

(c) Master switch arrangement for electrical circuits other than ignition. (See § 7.622 (c).)

(d) Source(s) of electrical energy. (See § 7.620.)

(e) Electrical protective devices. (See § 7.624.)

(f) Hand fire extinguishers. (See §§ 7.380 (a) and 7.381 and (f).)

(g) Windshield wiper or equivalent for each pilot statio (See § 7.351 (b).)

(h) Radio communication system (two-way).

(i) Ignition switch for each and all engines. (See § 7.472.)

§ 7.606 *Equipment, systems, and installations* — (a) *Functioning and reliability.* All equipment, systems, and installations, the functioning of which is necessary in showi compliance with the regulations in this subchapter, shall be designed and installed to insure that they will perform their intended functions reliably under all reasonably foreseeable operating conditions.

(b) *Hazards.* All equipment, systems, and installations shall be designed to safeguard against hazards to the rotorcra the event of their malfunctioning or failure.

(c) *Category A; power supply.* Where an installation, t functioning of which is necessary in showing compliance wit regulations in this subchapter, requires a power supply, such installation shall be considered an essential load on the powe supply, and the power sources and the system shall be capab supplying the following power loads in probable operating combinations and for probable durations:

(1) All loads connected to the system with the system functioning normally.

(2) All essential loads after failure of any one prime mov power converter, or energy storage device.

(3) All essential loads after failure of any one engine on or three-engine rotorcraft, or after

failure of any two engines on rotorcraft with four or more engines.

(4) In determining the probable operating combinations and durations of essential loads for the partial power failure conditions prescribed in subparagraphs (2) and (3) of this paragraph, it shall be permissible to assume that the power loads are reduced in accordance with a monitoring procedure which is consistent with safety in the type of operations authorized. If a particular load is not required to maintain controlled flight, it need not be considered for the two-engine-inoperative condition on rotorcraft with four or more engines as prescribed in subparagraph (3) of this paragraph.

INSTRUMENTS; INSTALLATION

§ 7.610 *General.* The provisions of §§ 7.611 through 7.613 shall apply to the installation of instruments in rotorcraft.

NOTE: It may be necessary to duplicate certain instruments at two or more crew stations to meet the instrument visibility requirements prescribed in § 7.611, or when required by the operating rules of the regulations in this subchapter for reliability or cross check purposes in particular types of operations. In this case independent operating systems are required in accordance with the provisions of § 7.612 (f).

§ 7.611 *Arrangement and visibility of instrument installations.* (a) Flight, navigation, and powerplant instruments for use by each pilot shall 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 out and forward along the flight path.

(b) The required instruments consisting of the air-speed indicator, gyroscopic direction indicator, gyroscopic bank and pitch indicator, gyroscopic turn and bank indicator, altimeter, rate-of-climb indicator, rotor tachometer(s), and manifold pressure indicator, shall be grouped and shall be centered as nearly as practicable about the vertical plane of the pilot's forward vision. Additional instruments considered of prime importance to the safe operation of the rotorcraft shall be included in the grouping.

(c) All other required powerplant instruments shall be closely grouped on the instrument panel.

(d) Identical powerplant instruments for the several engines shall be located to prevent any misleading impression as to the engines to which they relate.

(e) Powerplant instruments vital to the safe operation of the rotorcraft shall be plainly visible to the appropriate crew members.

(f) The vibration characteristics of the instrument panel shall be such as not to impair seriously the accuracy of the instruments or to damage them.

§ 7.612 *Flight and navigational instruments*—(a) *Air-speed indicating systems.* (1) Air-speed indicating instruments shall be calibrated to indicate true air speed at sea level in the standard atmosphere with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied to the instrument.

(2) The air-speed indicating system shall be calibrated to determine the system error; i.e., the relation between IAS and CAS. This calibration shall be determined over an appropriate range of speeds:

(i) In flight for the flight conditions of climb, level flight, an autorotation; and,

(ii) In ground effect during the accelerated take-off run.

(3) The air-speed error of the installation, including the air-speed indicator instrument calibration error, shall not exceed 3 percent or 5 mph, whichever is greater:

(i) Throughout the speed range in level flight at forward speeds of 10 mph or over, and

(ii) Through the speed range in climb of 10 mph below the take-off climb-out safety speed (see § 7.114 (a)) to 10 mph above the best rate-of-climb speed.

(4) The air-speed indicating system shall be arranged insofar as practicable to preclude malfunctioning or serious error due to the entry of moisture, dirt, or other substances.

(5) The air-speed indicating system shall be provided with a heated pitot tube or equivalent means of preventing malfunctioning due to icing.

(b) *Static air vent and pressure altimeter systems.* (1) All instruments provided with static air case connections shall be vented to the outside atmosphere through an appropriate piping system.

(2) The vent(s) shall be so located on the rotorcraft that its orifices will be least affected by air flow variation, moisture, or other foreign matter.

(3) The installation shall be such that the system will be airtight, except for the vent into the atmosphere.

(4) Pressure altimeters shall be of an approved type and shall be calibrated to indicate pressure altitude in standard atmosphere with a minimum practicable instrument calibration error when the corresponding static pressures are applied to the instrument.

(5) The design and installation of the altimeter system shall be such that the error indicated pressure altitude at sea level in standard atmosphere, excluding instrument calibration error, does not result in a reading more than 30 feet high nor more than 30 feet low in the level flight speed range 0 mph to 0.9 V_H

(c) *Magnetic direction indicator.* (1) The magnetic direction indicator shall be installed so that its accuracy will not be excessively affected by the rotorcraft's vibration or magnetic fields of a permanent or transient nature.

(2) After the magnetic direction indicator has been compensated, the calibration shall be such that the deviation in level flight does not exceed ±10° on any heading.

(3) A calibration placard shall be provided as specified in § 7.733.

(d) *Automatic pilot system.* If an automatic pilot system is installed, it shall be of an approved type, and the following shall be applicable:

(1) The system shall be so designed that the automatic pilot can either:

(i) Be quickly and positively disengaged by the human pilots to prevent it from interfering with their control of the rotorcraft, or

(ii) Be sufficiently overpowered by one human pilot to enable him to control the rotorcraft.

(2) A means shall be provided to indicate readily to the pilot the alignment of the actuating device in relation to the control system which it operates, except when automatic synchronization is provided.

(3) The manually operated control(s) for the system's operation shall be readily accessible to the pilots.

(4) The automatic pilot system shall be of such design and so adjusted that, within the range of adjustment available to the human pilot, it cannot produce hazardous loads on the rotorcraft or create hazardous deviations in the flight path under any conditions of flight appropriate to its use either during normal operation or in the event of malfunctioning, assuming that corrective action is initiated within a reasonable period of time.

(e) *Category A; instruments utilizing a power supply.* Each required flight instrument utilizing a power supply shall be provided with two independent sources of power, a means of selecting either power source, and a means of indicating the adequacy of the power being supplied to the instrument. The installation and power supply system shall be such that failure of any flight instrument connected to one source, or of the energy supply form one source, or a fault in any part of the power distribution system, will not interfere with the proper supply of energy from the other source. (See also §§ 7.606, 7.620, and 7.654.)

(f) *Duplicate instrument systems.* If duplicate flight instruments are required by the operating regulations in this subchapter (see note under § 7.610), the operating system for a duplicate instrument shall be completely independent of the operating system for the duplicated instrument. Additional instruments shall not be connected to the first pitot system. I additional instruments are connected to the other system, pro shall be made to disconnect or isolate in flight such additiona instruments.

§ 7.613 *Powerplant instruments*— (a) *Instrument lines.* (1) Powerplant instrument lines carrying flammable flui or gases under pressure shall be provided with restricted orif equivalent safety devices at the source of the pressure to pre the escape of excessive fluid or gas in case of line failure.

(2) The provisions of §§ 7.432 and 7.433 shall be made applicable to powerplant instrument lines.

(b) *Fuel quantity indicator.* Means shall be provided t indicate to the flight crew the quantity in gallons or equivaler of usable fuel in each tank during flight. The following shall

(1) Tanks, the outlets and air spaces of which are interconnected, shall be considered as one tank for the purpo providing separate indicators.

(2) Exposed sight gauges shall be protected against dar

(3) Fuel quantity indicators shall be calibrated to read ze during level flight when the quantity of fuel remaining in the t equal to the unusable fuel supply as defined by § 7.416. (See 7.736.)

(c) *Fuel flowmeter system.* When a flowmeter system is installed, the metering component shall include a means for b passing the fuel supply in the event that malfunctioning of th metering component results in a severe restriction to fuel flow

(d) *Oil quantity indicator*. A stick gauge or other equivalent means shall be provided to indicate the quantity of oil in each tank and in each transmission gear box. (See § 7.735.)

ELECTRICAL SYSTEMS AND EQUIPMENT

§ 7.620 *General.* The provisions of §§ 7.621 through 7.626 shall apply to all electrical systems and equipment (see also § 7.606).

§ 7.621 *Electrical system capacity*. The required generating capacity and the number and type of power sources shall be determined by an electrical load analysis and shall comply with §7.606.

§ 7.622 *Generating system.* (a) The generating system shall be considered to include electrical power sources, main power busses, transmission cables, and associated control, regulation, and protective devices.

(b) The generating system shall be so designed that the power sources function properly both when connected in combination and independently, and the failure or malfunctioning of any power source cannot create a hazard or impair the ability of the remaining sources to supply essential loads.

(c) Means accessible in flight to appropriate crew members shall be provided for the individual and collective disconnection of electrical power sources from the main bus.

(d) Means shall be provided to indicate to appropriate crew members those generating system quantities which are essential for the safe operation of the system.

NOTE: The voltage and current supplied by each generator are quantities considered essential.

§ 7.623 *Distribution system.* (a) The distribution system shall be considered to include all distribution busses, their associated feeders, and control and protective devices.

(b) Category A: Individual distribution systems shall be designed to insure that essential load circuits can be supplied in the event of reasonably probable faults or open circuits.

(c) Where two independent sources of electrical power for particular equipment or systems are required by the regulations in this subchapter, their electrical energy supply shall be assured.

NOTE: Various means may be used to assure a supply, such as duplicate electrical equipment, throw-over switching, and multi-channel or loop circuits separately routed.

§ 7.624 *Electrical protection.* (a) Automatic protective devices shall be provided to minimize distress to the electrical system and hazard to the rotorcraft in the event of wiring faults or serious malfunctioning of the system or connected equipment.

(b) Category A: In the generating system, means shall be provided to automatically de-energize and disconnect from the main bus any power source which develops hazardous overvoltage.

(c) All resettable type circuit protective devices shall be so designed that, when an overload or circuit fault exists, they will open the circuit irrespective of the position of the operating control.

(d) Protective devices or their controls used in essential load circuits shall be accessible for resetting in flight.

(e) Circuits for essential load shall have individual circuit protection.

NOTE: The provision does not necessarily require individual protection for each circuit in an essential load system; e.g., each position light in the system.

(f) If fuses are used, there shall be provided spare fuses for use in flight equal to at least 50 percent of the number of fuses of each rating required for complete circuit protection.

§ 7.625 *Electrical equipment and installation.* (a) In showing compliance with § 7.606 (a) and (b) with respect to the electrical system, equipment, and installation, consideration shall be given to critical environmental conditions.

NOTE: Critical environmental conditions may include temperature, pressure, humidity, ventilation, position, acceleration, vibration, and presence of detrimental substances.

(b) All electrical equipment, controls, and wiring shall be so installed that operation of any one unit or system of units will not affect adversely the simultaneous operation of any other electrical unit or system of units essential to the safe operation of the rotorcraft.

(c) Cables shall be grouped, routed, and spaced so that damage to essential circuits will be minimized in the event of faults in heavy current-carrying cables.

(d) Batteries and their installations shall provide for ventilation, drainage of fluids, venting of gases, and protection of other parts of the rotorcraft from corrosive battery fluids.

§ 7.626 *Electrical system fire and smoke protection.* The design and installation of all components of the electrical system shall comply with the pertinent fire and smoke protection provisions of §§ 7.358 (c) and 7.385. All electrical cables, terminals, and equipment which are necessary in emergency procedures and which are located in designated fire zones shall be fire-resistant.

Lights

§ 7.630 *Instrument lights.* (a) Instrument lights shall provide sufficient illumination to make all instruments, switches, etc., easily readable.

(b) Instrument lights shall be so installed that their direct rays are shielded from the pilot's eyes and so that no objectionable reflections are visible to him.

§ 7.631 *Landing lights.* (a) When landing or hovering lights are required, they shall be of an approved type.

(b) Landing lights shall be installed so that there is no objectionable glare visible to the pilot and so that the pilot is not adversely affected by halation.

(c) Landing lights shall be installed in a location where they provide the necessary illumination for night operation including hovering and landing.

(d) A switch for each light shall be provided, except that where multiple lights are installed at one location a single switch for the multiple lights shall be acceptable.

§ 7.632 *Position light system installation*— (a) *General.* In addition to this section, the provisions of §§ 7.633 through 7.635 shall be applicable to the position light system as a whole. The position light system shall include the items specified in paragraphs (b) through (f) of this section.

(b) *Forward position lights.* Forward position lights shall consist of a red and a green light spaced laterally as far apart as practicable and installed forward on the rotorcraft in such a location that, with the rotorcraft in normal flying position, the red light is displayed on the left side and the green light is displayed on the right side. The individual lights shall be of an approved type.

(c) *Rear position lights.* Rear position lights shall consist of a red and a white light mounted on the rotorcraft as far aft as practicable and located in close proximity to each other. Individual lights shall be of an approved type.

(d) *Fuselage lights.* Fuselage lights shall consist of two white lights installed approximately in the same vertical plane as the forward position lights. One of these lights shall be mounted on the top of the fuselage, the other on the bottom. The individual lights shall be of an approved type.

(e) *Flasher.* A position light flasher of an approved type shall be installed and shall comply with subparagraphs (1) through (3) of this paragraph.

(1) The flashing frequency shall not be less than 65 and not more than 85 flashes per minute.

(2) The sequence of position lights shall conform to eit one of the following:

(i) The forward position lights and fuselage lights flash simultaneously at the rate specified in subparagraph (1) of thi paragraph, with the rear red position light flashing simultaneo with one flash of the forward position and fuselage lights and rear white position light flashing simultaneously with the nex of the forward position and fuselage lights, or

(ii) The forward position lights and fuselage lights flash alternately at the rate specified in subparagraph (1) of this paragraph, with the rear white light flashing simultaneously w the forward position lights and the rear red light flashing simultaneously with the fuselage lights.

(3) A switch shall be provided in the system to disconn the flasher from the circuit so that continuous light can be su by the forward position lights and the rear white position ligh with the remaining lights de-energized.

(f) *Light covers and color filters.* Light covers or colo filters used shall be of flame-resistant material and shall be constructed so that they will not change color or shape or su any appreciable loss of light transmission during normal use.

§ 7.633 *Position light system dihedral angles.* The forward and rear position lights as installed on the rotorcraft s show unbroken light within dihedral angles specified in para (a) through (c) of this section.

(a) Dihedral angle L (left) shall be considered formed by intersecting vertical planes, one parallel to the longitudinal ax the rotorcraft and the other at 110° to the left of the first, whe looking forward along the longitudinal axis.

(b) Dihedral angle R (right) shall be considered formed l two intersecting vertical planes, one parallel to the longitudina of the rotorcraft and the other at 110° to the right of the first, when looking forward along the longitudinal axis.

(c) Dihedral angle A (aft) shall be considered formed by two intersecting vertical planes making angles of 70° to the right and 70° to the left, respectively, looking aft along the longitudinal axis, to a vertical plane passing through the longitudinal axis.

§ 7.634 *Position light distribution and intensities*—
(a) *General.* The intensities prescribed in this section are those to be provided by new equipment with all light covers and color filters in place. Intensities shall be determined with the light source operating at a steady value equal to the average luminous output of the light source at the normal operating voltage of the rotorcraft. The light distribution and intensities of position lights shall comply with the provisions of paragraphs (b) and (c) of this section.

(b) *Forward and rear position lights.* The light distribution and intensities of forward and rear position lights shall 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 L, R, and A, and shall comply with the provisions of subparagraphs (1) through (3) of this paragraph.

(1) *Intensities in horizontal plane.* The intensities in the horizontal plane shall not be less than the values given in Figure 7-1. (The horizontal plane is the plane containing the longitudinal axis of the rotorcraft and is perpendicular to the plane of symmetry of the rotorcraft.)

(2) *Intensities above and below horizontal.* The intensities in any vertical plane shall not be less than the appropriate value given in Figure 7-2, where I is the minimum intensity prescribed in Figure 7-1 for the corresponding angles in the horizontal plane. (Vertical planes are planes perpendicular to the horizontal plane.)

(3) *Overlaps between adjacent signals.* The intensities in overlaps between adjacent signals shall not exceed the values given in Figure 7-3, except that higher intensities in the overlaps shall be acceptable with the use of main beam intensities substantially greater than the minima specified in Figure 7-1 and 7-2 if the overlap intensities in relation to the main beam intensities are such as not to affect adversely signal clarity.

(c) *Fuselage lights.* The illuminating intensity of the top and the bottom fuselage lights individually shall be equivalent to that which would be furnished by a 32-candlepower lamp installed in a reflector of high reflective properties. The lights shall have a clear cover and the light distribution shall be reasonably uniform throughout approximately a hemisphere.

Dihedral angle (light involved)	Angle from right or left of longitudinal axis, measured from dead ahead	Intensity (candles)
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
A (rear red)-----------------	110° to 180°	4

Figure 7-1—Minimum Intensities in the Horizontal Plane of Forward and Rear Position Lights

Angle above or below horizontal	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°----------------	At least 2 candles.

Figure 7-2—Minimum Intensities in any Vertical Plane of Forward and Rear Position Lights

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

Figure 7-3—Maximum Intensities in Overlapping Beams of Forward and Rear Position Lights

NOTE: Area A includes all directions in the adjacent dihedral angle which pass through the light source and which intersect the common boundary plane at more than 10 degrees but less than 20 degrees. Area B includes all directions in the adjacent dihedral angle which pass through the light source and which intersect the common boundary plane at more than 20 degrees.

§ 7.635 *Color specifications.* The colors of the position lights shall have the International Commission on Illumination chromaticity coordinates as set forth in paragraphs (a) through (c) of this section.

(a) *Aviation red.*

"y" is not greater than 0.335,

"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,

"y" is not less than 0.390 - 0.170x;

(c) *Aviation white.*

"x" is not less than 0.350,

"x" is not greater than 0.540,

"y"—"yo" is not numerically greater than 0.01.

"yo" being the "y" coordinate of the Planckian radiator for which xo=x.

§ 7.636 *Riding light.* (a) When a riding (anchor) light is required for a rotorcraft operated from water, it shall be capable of showing a white light for at least 2 miles at night under clear atmospheric conditions.

(b) Riding lights shall be installed so that they will show a maximum practicable unbroken light when the rotorcraft is moored or drifting on the water. Externally hung lights shall be permitted.

§ 7.637 *Anti-collision light.* In addition to the position light system prescribed in §§ 7.632 through 7.635, an approved anti-collision light shall be installed.

SAFETY EQUIPMENT

§ 7.640 *General.* Required safety equipment which the crew is expected to operate at a time of emergency such as flares and automatic life-raft releases, shall be readily accessible. (See also §7.738 (e).)

§ 7.641 *Flares.* When parachute flares are installed, they shall be of an approved type and installed in accordance with § 7.642.

§ 7.642 *Flare installation.* (a) Parachute flares shall be releasable from the pilot compartment and installed to minimize the danger of accidental discharge.

(b) It shall be demonstrated in flight that the flare installation is such that ejection can be accomplished without hazard to the rotorcraft and its occupants.

(c) If recoil loads are involved in the ejection of the flares, the structure of the rotorcraft shall be designed to withstand such loads.

§ 7.643 *Safety belts.* Safety belts shall be of an approved type (see § 7.355 (c) (2)). When means are provided to indicate to the passengers when seat belts should be fastened, the device shall be so installed that it can be operated from the seat of either the pilot or copilot.

§ 7.644 *Emergency flotation and signaling equipment.* When emergency flotation and signaling equipment is requir the operating rules of the regulations in this subchapter, such equipment shall comply with the provisions of paragraphs (a) through (d) of this section.

(a) *Life rafts.* Life rafts shall be of an approved type. Unless excess rafts of sufficient capacity are provided, the buoyancy and seating capacity beyond the rated capacity of rafts shall be such as to accommodate all occupants of the rotorcraft in the event of a loss of one life raft of the largest ra capacity on board. Each life raft shall be equipped with a trail line and with a static line, the latter designed to hold the raft n the rotorcraft but to release it in case the rotorcraft becomes t submerged. Each raft shall contain obvious markings of instr on its operation.

(b) *Life-raft equipment.* Approved equipment intended for survival shall be attached to each life raft and marked for identification and method of operation.

Note: The extent and type of survival equipment will dep upon the route over which the rotorcraft is operated.

(c) *Long-range signaling device.* An approved long-range signaling device shall be provided for use in one of the rafts.

(d) *Life preservers.* Life preservers shall be of an appro type. They shall be reversible and shall contain obvious mar of instruction on their use.

§ 7.645 *Stowage of safety equipment.* Special stowage provisions shall be made for all prescribed safety equipment used in emergencies. The stowage provisions shall be such equipment is directly accessible and its location is obvious. safety equipment shall be protected against inadvertent dama The stowage provisions shall be marked conspicuously to ide the contents and to facilitate removal of the equipment. In addition, the following shall specifically apply:

(a) *Emergency exit means.* The stowage provisions for the emergency exit descent device required by § 7.357 (d) (6) shall be located at the exits which they are intended to serve.

(b) *Life rafts.* Life rafts shall be stowed near exits through which the rafts can be launched during an unplanned ditching. Rafts automatically or remotely released on the outside of the rotorcraft shall be attached to the rotorcraft by means of the static line prescribed in § 7.644 (a).

(c) *Long-range signaling device.* The stowage provisions for the long-range signaling device required by § 7.644 (c) shall be located near an exit to be available during an unplanned ditching.

(d) *Life preservers.* Life preservers shall be so located that they are within easy reach of each occupant while seated.

§ 7.646 *Oxygen equipment and supply*— (a) *Protective breathing equipment.* When protective breathing equipment is required by the operating rules of the regulations in this subchapter, it shall be designed to protect the flight crew from the effects of smoke, carbon dioxide, and other harmful gases while on flight deck duty. The protective breathing equipment and the necessary supply of oxygen shall be in accordance with the following of provisions:

(1) The protective breathing equipment shall include masks covering the eyes, nose, and the mouth, or only the nose and mouth where accessory equipment is provided to protect the eyes.

(2) A supply of protective oxygen per crew member shall be of 10 minutes duration at a pressure altitude of 8,000 feet and a respiratory minute volume of 30 liters per minute BTPD.

NOTE: When a demand-type oxygen system is employed, a supply per crew member of 200 liters of free oxygen at 70°F. and 760 mm. Hg pressure is considered to be of 10 minutes duration at the prescribed altitude and minute volume. BTPD refers to body temperature conditions; i.e., 37°C. at ambulant pressure, dry.

Miscellaneous Equipment

§ 7.650 *Hydraulic systems; strength*— (a) *Structural loads.* All elements of the hydraulic system shall be designed to withstand, without detrimental permanent deformation, all structural loads which may be imposed simultaneously with the maximum hydraulic loads occurring in operation.

(b) *Proof pressure tests.* All elements of the hydraulic system shall be tested to a proof pressure of 1.5 times the maximum pressure to which the part will be subjected in normal operation. In such test, no part of the hydraulic system shall fail, malfunction, or suffer detrimental deformation.

(c) *Burst pressure strength.* Individual hydraulic system elements shall be designed to withstand pressures which are sufficiently increased over the pressures prescribed in paragraph (b) of this section to safeguard against rupture under service conditions.

NOTE: The following pressures, in terms of percentages of maximum operating pressures of particular elements, in most instances are sufficient to insure against rupture in service: 250 percent in units under oil pressure; 400 percent in units containing air and oil under pressure and in lines, hoses, and fittings; and 300 percent in units of system subjected to back pressure.

§ 7.651 *Hydraulic systems; design.* The provisions of § 7.606 shall apply to hydraulic systems and equipment.

(a) *Pressure indication.* A means shall be provided to indicate the pressure in each main hydraulic power system.

(b) *Pressure limiting provisions.* Provision shall be made to assure that pressure in any part of the system will not exceed a safe limit above the maximum operating pressure of the system and to insure against excessive pressure resulting from fluid volumetric changes in all lines which are likely to remain closed long enough for such changes to take place. In addition, consideration shall be given to the possible occurrence of detrimental transient (surge) pressures during operation.

(c) *Installation.* Hydraulic lines, fittings, and components shall be installed and supported to prevent excessive vibration and to withstand inertia loads. All elements of the installation shall be protected from abrasion, corrosion, and mechanical damage.

(d) *Connections.* Flexible hose, or other means of providing flexibility, shall be used to connect points in a hydraulic fluid line between which there is relative motion or differential vibration.

§ 7.652 *Hydraulic system fire protection.* When flammable type hydraulic fluid is used, the hydraulic system shall comply with the provisions of §§ 7.384 and 7.481 through 7.483.

§ 7.653 *Radio installation.* (a) Radio communication and navigational equipment installations in the rotorcraft should be free from hazards in themselves, in their method of operation, and in their effects on other components of the rotorcraft. In showing compliance with this requirement, consideration shall be given to critical environmental conditions.

NOTE: Critical environmental conditions may include temperature, pressure, humidity, ventilation, position, acceleration, vibration, and presence of detrimental substances.

(b) All radio communication and navigational equipment, controls, and wiring shall be so installed that operation of any one unit or system of units will not affect adversely the simultaneous operating of any other radio or electronic unit or system of units required by the regulations in this subchapter.

§ 7.654 *Vacuum systems.* (a) Means, in addition to the normal pressure relief, shall be provided to relieve automatically the pressure in the discharge lines from the vacuum air pump if the delivery temperature of the air reaches an unsafe value.

(b) Vacuum air system lines and fittings on the discharge side of the pump which might contain flammable vapors or fluids shall comply with §7.483 if they are located in a designated fire zone. Other vacuum air system components located in designated fire zones shall be fire-resistant.

SUBPART G—OPERATING LIMITATIONS AND INFORMATION

GENERAL

§ 7.700 *Scope.* (a) The operating limitations in §§ 7.710 through 7.718 shall be established as prescribed in this part.

(b) The operating limitations, together with any other information concerning the rotorcraft found necessary for safety during operation, shall be included in the Rotorcraft Flight Manual (§ 7.740), shall be expressed as markings and placards (§ 7.730), and shall be made available by such other means as will convey the information to the crew members.

OPERATING LIMITATIONS

§ 7.710 *Air-speed limitations; general.* When air-speed limitations are a function of weight, weight distribution, altitude, rotor speed, power, or other factors, the values corresponding with all critical combinations of these values shall be established.

§ 7.711 *Never-exceed speed V_{NE}.* (a) The never-exceed speed shall be established. It shall not be less than the best rate-of-climb speed with all engines operating at maximum continuous power, nor greater than either of the following:

(1) 0.9 V established in accordance with § 7.204, or

(2) 0.9 times the maximum speed demonstrated in accordance with § 7.140.

(b) It shall be permissible to vary the never-exceed speed with altitude and rotor rpm, provided that the ranges of these variable are sufficiently large to allow an operationally practical and safe variation of the never-exceed speeds.

§ 7.712 *Operating speed range.* An operating speed range shall be established for each rotorcraft.

§ 7.713 *Rotor speed.* Rotor rpm limitations shall be established as set forth in paragraphs (a) and (b) of this secti (See also § 7.710.)

(a) *Maximum power off (autorotation.)* Not to exceed 95 percent of the maximum design rpm determined under § 7.2 (b) or 95 percent of the maximum rpm demonstrated during th type tests (see § 7.103 (b)), whichever is less.

(b) *Minimum*— (1) *Power off.* Not less than 105 percen of the higher of the following:

(i) The minimum demonstrated during the type test (see 7.103 (b)), or

(ii) The minimum determined by design substantiation.

(2) *Power on.* Not less than the higher of the following

(i) The minimum demonstrated during the type tests (se 7.103 (a)), or

(ii) The minimum determined by design substantiation a not higher than a value determined in compliance with § 7.103

§ 7.714 *Powerplant limitations.* The powerplant limitations set forth in paragraphs (a) through (d) of this secti shall be established for the rotorcraft. They shall not exceed corresponding limits established as a part of the type certifica of the engine(s) installed on the rotorcraft.

(a) *Take-off operation.* The take-off operation shall be limited by:

(1) The maximum rotational speed, which shall not be g than the maximum value determined by the rotor design, nor g than the maximum value demonstrated during type tests.

(2) The maximum permissible manifold pressure.

(3) The time limit for use of the power which corresponds with the value established in subparagraphs (1) and (2) of this paragraph.

(4) Where the time limit established in subparagraph (3) this paragraph exceeds two

minutes, the maximum allowable cylinder head or coolant outlet and oil temperatures.

(5) Maximum cylinder head or coolant outlet and oil temperatures, if these differ from the maximum limits for continuous operation.

(b) *Continuous operation.* The continuous operation shall be limited by:

(1) The maximum rotational speed, which shall not be greater than the maximum value determined by the rotor design, nor greater then the maximum value demonstrated during type tests.

(2) Maximum permissible manifold pressure.

(3) Maximum allowable cylinder head or coolant outlet and oil temperatures.

(4) The minimum rotational speed demonstrated in compliance with the rotor speed requirements as prescribed in § 7.713 (b) (2).

(c) *Fuel octane rating.* The minimum octane rating of fuel required for satisfactory operation of the powerplant within the limitations prescribed in paragraphs (a) and (b) of this section.

(d) *Cooling limitations.* The maximum sea level temperature for which satisfactory cooling has been demonstrated.

§ 7.715 *Limiting height-speed envelope.* If a range of heights exists at any speed, including zero, within which it is not possible to make a safe landing following power failure, the range of heights and its variation with forward speed shall be established together with any other pertinent information, such as type of landing surface. (See §§ 7.11 (a) (1), 7.111 (b), and 7.741 (f).)

§ 7.716 *Rotorcraft weight and center of gravity limitations.* The rotorcraft weight and center of gravity limitations to be established are those required to be determined by §§ 7.101 and 7.102.

§ 7.717 *Minimum flight crew.* The minimum flight crew shall be established by the Administrator as that number of persons which he finds necessary for safety in the operations authorized under § 7.718. This finding shall be based upon the workload imposed upon individual crew members with due consideration given to the accessibility and the ease of operation of all necessary controls by the appropriate crew members.

§ 7.718 *Types of operation.* The type of operation to which a rotorcraft is limited shall be established on the basis of flight characteristics and the equipment installed. (See the operating parts of this subchapter.)

§ 7.719 *Maintenance manual.* The applicant shall furnish with each rotorcraft a maintenance manual to contain information which he considers essential for the proper maintenance of the rotorcraft. The maintenance manual shall include recommended limits on service life or retirement periods for major components of the rotorcraft. Such components shall be identified by serial numbers of by other equivalent means.

MARKINGS AND PLACARDS

§ 7.730 *General.* (a) The markings and placards specified in §§ 7.731 through 7.738 are required for all rotorcraft.

(b) Markings and placards shall be displayed in conspicuous places and shall be such that they cannot be easily erased, disfigured, or obscured.

(c) Additional information, placards, and instrument markings having a direct and important bearing on safe operation of the rotorcraft shall be required when unusual design, operating, or handling characteristics so warrant.

§ 7.731 *Instrument markings; general.* (a) When markings are placed on the cover glass of the instrument, provision shall be made to maintain the correct alignment of the glass cover with the face of the dial.

(b) All arcs and lines shall be of sufficient width and so located that they are clearly visible to the pilot.

§ 7.732 *Air-speed indicator.* Instrument indications shall be in terms of indicated air speed. The markings set forth in paragraphs (a) through (c) of this section shall be used to indicate to the pilot the maximum and minimum permissible speeds and the normal precautionary operating ranges. (See §§ 7.682 (a), 7.710, 7.711, 7.712, 7.713, and 7.715.)

(a) A red radial line shall be used to indicate the limit beyond which operation is dangerous.

(b) A yellow arc shall be used to indicate the precautionary operating range.

(c) A green arc shall be used to indicate the safe operating range.

§ 7.733 *Magnetic direction indicator.* A placard shall be installed on or in close proximity to the magnetic direction in dictator which shall comply with the requirements of paragraphs (a) through (c) of this section. (See § 7.612 (c).)

(a) The placard shall contain the calibration of the instrument in a level flight attitude with engine(s) operating.

(b) The placard shall state whether the calibration was made with radio receiver(s) on or off.

(c) The calibration readings shall be in terms of magnetic headings in not greater than 45° increments.

§ 7.734 *Powerplant instruments; general.* All required powerplant instruments shall be marked as follows:

(a) The maximum and the minimum, if applicable, safe operational limits shall be marked with red radial lines.

(b) The normal operating ranges shall be marked with a green arc not extending beyond the maximum and minimum safe operational limits.

(c) The take-off and precautionary ranges shall be marked with a yellow arc.

(d) Engine or rotor speed ranges which are restricted because of excessive vibration stresses shall be marked with red arcs.

§ 7.735 *Oil quantity indicator.* Oil quantity indicators shall be marked in sufficient increments to indicate readily and accurately the quantity of oil. (See § 7.613 (d).)

§ 7.736 *Fuel quantity indictor.* When the unusable fuel supply for any tank exceeds 1 gallon or 5 percent of the tank capacity, whichever is greater, a red arc shall be marked on the indicator extending from the calibrated zero reading to the lowest reading obtainable in the level flight attitude. (See §§ 7.421 and 7.613 (b).) A notation in the Rotorcraft Flight Manual shall be made to indicate that the fuel remaining in the tank when the quantity indicator reaches zero is not usable in flight. (See § 7.741 (g).)

§ 7.737 *Control markings*— (a) *General.* All cockpit controls including those referred to in paragraphs (b) and (c) of this section shall be plainly marked as to their function and method of operation. (See § 7.353.)

(b) *Powerplant fuel controls.* The powerplant fuel controls shall be marked in accordance with subparagraphs (1) through (4) of this paragraph.

(1) Controls for fuel tank selector valves shall be marked to indicate the position corresponding with each tank with all existing cross-feed positions.

(2) When more than one fuel tank is provided, and if safe operation depends upon the use of tanks in a specific sequence, the fuel tank selector controls shall be marked adjacent to or on the control to indicate to the flight personnel the order in which the tanks must be used.

(3) On multiengine rotorcraft controls for engine valves shall be marked to indicate the position corresponding with each engine.

(4) The capacity of each tank shall be indicated adjacent to or on the fuel tank selector control.

(c) *Accessory and auxiliary controls.* Accessory and auxiliary controls shall be marked in accordance with subparagraphs (1) and (2) of this paragraph.

(1) Where visual indicators are essential to the operatio the rotorcraft (such as a rotor pitch or retractable landing gea indicator), they shall be marked in such a manner that the cre members at all times can determine the position of the unit.

(2) Emergency controls shall be colored red and shall b marked to indicate their method of operation.

§ 7.738 *Miscellaneous markings and placards*— (a) *Baggage compartments and ballast location.* Each baggage and cargo compartment as well as the ballast location shall be placard stating the maximum allowable weight of contents and applicable, any other limitation on contents found necessary loading requirements. When the maximum permissible weigh carried in a seat is less than 170 pounds (see § 7.102 (b)), a pl shall be permanently attached to the seat structure stating th maximum allowable weight of the occupant to be carried.

(b) *Fuel and oil filler openings.* The information required by subparagraphs (1) and (2) of this paragraph shall marked on or adjacent to the appropriate filler cover.

(1) The word "fuel," the minimum permissible fuel octar number for the engines installed, and the usable fuel tank cap (See § 7.425 (a).)

(2) The word "oil" and the oil tank capacity. (See § 7.44 (b) (4).)

(c) *Emergency exit placards.* Emergency exit placards and operating controls shall be colored red. A placard shall b located adjacent to the controls which clearly indicates the lo of the exit and the method of operation. (See § 7.357.)

(d) *Operating limitation placard.* A placard shall be provided in clear view of the pilot stating: "This (helicopter, gyrodyne, etc.) must be operated in compliance with the oper limitations specified in the CAA approved Rotorcraft Flight Manual."

(e) *Safety equipment.* (1) Safety equipment controls which the crew is expected to operate in time of emergency, such as flares, automatic life raft releases, etc., shall be plainly marked as to their method of operation.

(2) When fire extinguishers and signaling and other life-saving equipment are carried in lockers, compartments, etc., these locations shall be marked accordingly.

ROTORCRAFT FLIGHT MANUAL

§ 7.740 *General.* (a) A Rotorcraft Flight Manual shall be furnished with each rotorcraft.

(b) The portions of the manual listed in §§ 7.741 through 7.744 as are appropriate to the rotorcraft shall be verified and approved and shall be segregated, identified, and clearly distinguished from portions not so approved.

(c) Additional items of information having a direct and important bearing on safe operation shall be required when unusual design, operating, or handling characteristics so warrant.

§ 7.741 *Operating limitations.* The operating limitations set forth in paragraphs (a) through (g) of this section shall be furnished with each rotorcraft.

(a) *Air-speed and rotor limitations.* Sufficient information necessary for the markings of the limitations on or adjacent to the indicators shall be furnished. (See § 7.732.) In addition, the significance of the limitations and of the color coding used shall be explained.

(b) *Powerplant limitations.* Information shall be included to outline and to explain all powerplant limitations (see § 7.714) and to permit marking the instruments as required by §§ 7.734 through 7.736.

(c) *Weight and loading distribution.* The rotorcraft weights and center of gravity limits required by §§ 7.101 and 7.102 shall be included, together with the items of equipment on which the empty weight is based. Where the variety of possible loading conditions warrants, instructions shall be included to facilitate observance of the limitations.

(d) *Flight crew.* When a flight crew of more than one is required, the number and functions of the minimum flight crew determined in accordance with § 7.717 shall be described.

(e) *Type of operation.* The type(s) of operation(s) shall be listed for which the rotorcraft and its equipment installations have been approved. (See § 7.718.)

(f) *Limiting heights.* Sufficient information shall be included to outline the limiting heights and corresponding speeds for safe landing after power failure. (See § 7.715.)

(g) *Unusable fuel.* If the unusable fuel supply in any tank exceeds one gallon or 5 percent of the tank capacity, whichever is greater, warning shall be provided to indicate to the flight personnel that the fuel remaining in the tank when the quantity indicator reads zero cannot be used safely in flight. (See § 7.421.)

§ 7.742 *Operating procedures.* The section of the manual devoted to operating procedures shall contain information concerning normal and emergency procedures and other pertinent information peculiar to the rotorcraft's operating characteristics which are necessary for safe operation. If applicable, the procedures to be followed in the event of engine failure including minimum speeds, trim, operation of remaining engines, etc., shall be described.

§ 7.743 *Performance information* — (a) *Category A; performance data.* A summary of all performance data shall be given, including performance data necessary for the application of the operating rules of this subchapter, together with descriptions of the conditions, air speeds, etc., under which these data were determined. In addition, the information required by subparagraphs (1) through (3) of this paragraph shall be included.

(1) *Air speeds.* The indicated air speeds corresponding with those determined for take-off shall be listed together with the procedures to be followed in the event the critical engine becomes inoperative during take-off (see § 7.742). Airspeed calibrations shall be included. (See § 7.612 (a) (2) and (3).)

(2) *Autorotative landing technique.* Description of the techniques, associated airspeed, and rates of descent for autorotative landings shall be included. (See § 7.118 (b).)

(3) *Maximum allowable wind.* Information relative to the maximum allowable wind for safe operation near the ground shall be included. (See § 7.121 (d).)

(b) *Category B; performance information.* Information relative to the items of performance set forth in subparagraphs (1) through (5) of this paragraph, including any additional performance data necessary for the application of the operating rules of this subchapter, shall be given.

(1) The take-off distance and the take-off safety air speed together with any pertinent information

defining the flight path with respect to the required autorotative landing in the event of an engine failure, including the calculated effect of altitude and temperature. (See § 7.114.)

(2) The steady rates of climb and hovering ceiling together with the corresponding air speeds and other pertinent information, including the calculated effect of altitude and temperature. (See §§7.115 and 7.116.)

(3) The landing distance, appropriate glide air speed, and the type of landing surface together with any pertinent information which might affect this distance, including the calculated effect of altitude and temperature. (See §§ 7.117 and 7.118.)

(4) Maximum wind allowable for safe operation near the ground (see § 7.121 (d)).

(5) The air-speed calibrations. (See § 7.612 (a) (2) and (3).)

§ 7.744 *Marking and placard information.* (See § 7.730.)

ROTORCRAFT IDENTIFICATION DATA

§ 7.750 *Identification plate.* A fire-proof identification plate shall be securely attached to the structure in an accessible location where it will not likely be defaced during normal service. The identification plate shall not be placed in a location where it might be expected to be destroyed or lost in the event of an accident. The identification plate shall contain the identification data required by §.50 of this subchapter.

§ 7.751 *Identification marks.* The nationality and registration marks shall be permanently affixed in accordance with § 1.100 of this subchapter.

By the Civil Aeronautics Board.
[SEAL]

M. C. Mulligan,
Secretary.

[F.R. Doc. 56-4354; Filed, June 1, 1956;
8:56 a.m.]