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CIVIL AIR REGULATIONS

PART 6—ROTOCRAFT AIRWORTHINESS; NORMAL CATEGORY

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TITLE 14—CIVIL AVIATION

Chapter I—Civil Aeronautics Board

Subchapter A—Civil Air Regulations

PART 6—ROTOCRAFT AIRWORTHINESS; NORMAL CATEGORY

REVISION OF PART

Because of the number of outstanding amendments to Part 6 there follows a revision of Part 6 incorporating all amendments thereto which were in effect on December 20, 1956.

By the Civil Aeronautics Board.

[SEAL] M. C. MULLIGAN, *Secretary.*

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AUTHORITY: §§ 6.0 to 6.751 issued under sec. 205, 52 Stat. 984, as amended; 49 U. S. C. 425. Interpret or apply secs. 601, 603, 52 Stat. 1007, as amended, 1009, as amended; 49 U. S. C. 551, 553.

SUBPART A—GENERAL

APPLICABILITY AND DEFINITIONS

§ 6.0 *Applicability of this part.* This part contains standards with which compliance shall be demonstrated for the issuance of and changes to type certificates for rotorcraft. This part, until superseded or rescinded, shall apply to rotorcraft of any weight for which applications for type certification under this part were made between the effective date of this part (January 15, 1951) and August 1, 1956. For applicaitons for type certificates made after August 1, 1956, this part shall apply only to rotorcraft which have a maximum weight of 6,000 pounds or less.

§ 6.1 *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 rotocraft 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 § 6.18.)

(b) *Rotorcraft types*—(1) *Rotorcraft.* A rotocraft 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 P_o at sea level under the above conditions is 0.002378 pound sec^2/ft^4.

(2) *Maximum anticipated air temperature.* The maximum anticipated air temperature is a temperature specified for the purpose of compliance with the powerplant cooling standards. (See § 6.451.)

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

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

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

(6) *Ground resonance.* Ground resonance is the mechanical instability encountered when the rotorcraft is in contact with the ground.

(7) *Mechanical instability.* Mechanical instability is an unstable resonant condition due to the interaction between the rotor blades and the rotorcraft structure while the rotorcraft is on the ground or airborne.

(d) *Weights*—(1) *Maximum weight.* The maximum weight of the rotorcraft is that maximum at which compliance with the requirements of this part is demonstrated. (See § 6.101.)

(2) *Minimum weight.* The minimum weight of the rotorcraft is that minimum at which compliance with the requirements of this part is demonstrated. (See § 6.101.)

(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 § 6.104.)

(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 § 6.101.)

(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 § 6.101.)

(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 §§ 6.612 and 6.732.)

(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 air-speed 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. ($TAS = EAS\ (p_o/\rho)^{1/2}$)

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

(6) V_{NE}. The never-exceed speed. (See § 6.711.)

(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 § 6.200.)

(2) *Ultimate load.* An ultimate load is a limit load multiplied by the appropriate factor of safety. (See § 6.200.)

(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 § 6.200.)

(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 § 6.307 (d).)

(g) *Power installation*[1]—(1) *Brake horsepower.* Brake horsepower is the power delivered at the propellor 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 take-off, 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 stated, the critical altitude is the maximum altitude at which it is 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:

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

where:

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

α=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 (radians 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 the 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.

CERTIFICATION

§ 6.10 *Eligibility for type certificates.* A rotorcraft shall be eligible for type certification under the provisions of this part if it complies with the airworthiness provisions hereinafter established or if the Administrator finds that the provision or provisions not complied with are compensated for by factors which provide an equivalent level of safety: *Provided,* That the Administrator finds no feature or characteristic of the rotorcraft which renders it unsafe.

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

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

(b) If the interval between the date of application for type certificate and the issuance of the corresponding type certificate exceeds three years, a new application for type certificate shall be required, except that for applications pending on May 1, 1954, such three-year period shall commence on that date. At the option of the applicant, a new application may be filed prior to the expiration of the three-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 § 6.13 (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 § 6.13 (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 § 6.13 (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 incorpo-

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

[2] For propeller airworthiness requirements see Part 14 of this subchapter.

[3] See NACA Technical Note No. 1604.

rated by reference at the time of issuance of the type certificate.

NOTE: Examples 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.

§ 6.12 *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 § 6.11.)

§ 6.13 *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 § 6.14 (b)), the operating limitations for the rotorcraft (see § 6.700), 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 § 6.12 shall be considered as incorporated in the type certificate as though set forth in full.

§ 6.14 *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.

§ 6.15 *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.

§ 6.16 *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 § 6.412.

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

§ 6.18 *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 allow approval of materials, parts, processes, and appliances under the system of Technical Standard Orders, or in conjunction with type certification procedures for a rotorcraft, or by any other form of approval by the Administrator.

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

§ 6.19 *Changes in type design.* (For requirements with regard to changes in type design and the designation of applicable regulations therefor, see § 6.11 (d) and (e), and Part 1 of this subchapter.)

SUBPART B—FLIGHT

GENERAL

§ 6.100 *Proof of compliance.* (a) Compliance with the requirements prescribed in this subpart shall be established by flight or other tests conducted upon a rotorcraft of the type for which a certificate of airworthiness is sought or by calculations 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 reasonably 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 Administrator's representative shall conduct any flight tests which he finds necessary to check the calibration and correction report.

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§ 6.101 *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 of the applicable flight requirements has been demonstrated.

(b) The maximum weight shall not be less than the sum of the weights of the following:

(1) The empty weight in accordance with § 6.104;

(2) Usable fuel appropriate to the operation contemplated with full payload;

(3) The full oil capacity; and

(4) 170 pounds in all seats, except that when the maximum permissible weight to be carried in a seat is less than 170 pounds it shall be acceptable to use this lesser weight. (See § 6.738 (a).)

(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.

(d) The minimum weight shall not exceed the sum of the weights of the following:

(1) The empty weight in accordance with § 6.104;

(2) The minimum crew necessary to operate the rotorcraft, assuming for each crew member the lowest of the following:

(i) 170 pounds,

(ii) Weight selected by the applicant, and

(iii) Weight included in the loading instructions (see §§ 6.102 (b) and 6.738 (a)); and

(3) Oil in the quantity determined in accordance with the provisions of § 6.440 (b).

§ 6.102 *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 § 6.101 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 § 6.101, 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 § 6.741 (c).)

§ 6.103 *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 §§ 6.713 (b) (2) and 6.714 (b)). A means shall be provided to prevent rotational speeds substantially less than the approved minimum rotor rpm in any flight condition with pitch control of the main rotor(s) in the high-pitch position, and with the engine(s) operating within the approved limitations. 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 §§ 6.713 (a) and 6.713 (b) (1)). A rotor blade low-pitch limiting device shall be positioned to provide rotational speeds 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.

§ 6.104 *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 § 6.421), 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 § 6.740.)

§ 6.105 *Use of ballast.* Removable ballast may be used to enable the rotorcraft to comply with the flight requirements. (See §§ 6.391, 6.738, and 6.740.)

PERFORMANCE

§ 6.110 *General.* The performance information prescribed in §§ 6.111 through 6.115 shall be determined, and the rotorcraft shall comply with the corresponding requirements in the standard atmosphere in still air.

§ 6.111 *Take-off.* The take-off shall be demonstrated at maximum certificated weight, forward center of gravity, and using take-off power at take-off rpm and made in a manner such that a landing can be made safely at any point along the flight path in case of an engine failure and shall not require an exceptional degree of skill on the part of the pilot or exceptionally favorable conditions. Pertinent information concerning the take-off procedure, including the type of take-off surface and appropriate climb-out air speeds, shall be specified in the operating procedures section of the Rotorcraft Flight Manual. (See §§ 6.715, 6.740, and 6.742.)

§ 6.112 *Climb.* (a) For all rotorcraft, except helicopters, the steady rate of climb at the best rate-of-climb speed with maximum continuous power and landing gear retracted shall be determined over the range of weights, altitudes, and temperatures for which certification is sought (see § 6.740). This rate of climb shall provide a steady angle of climb under standard sea level conditions of not less than 1:6.

(b) For helicopters the best rate-of-climb speed shall be determined at standard sea level conditions at maximum certificated weight with all engines operating at maximum continuous power.

(c) For multiengine helicopters the steady rate of climb or descent shall be determined at maximum certificated weight, at the best rate-of-climb or descent speed, with one engine inoperative, and the remaining engine(s) operating at maximum continuous power.

§ 6.113 *Minimum operating speed performance.* (a) Hovering ceilings for helicopters shall be determined over the range of weights, altitudes, and temperatures for which certification is sought with take-off power and landing gear extended in the ground effect at a height above the ground consistent with normal take-off procedures.

(b) At maximum weight, under standard atmospheric conditions, and under conditions prescribed in paragraph (a) of this section, 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.

§ 6.114 *Autorotative or one-engine-inoperative landing.* Landings shall be demonstrated in accordance with the provisions of paragraphs (a) through (d) of this section. Pertinent information concerning the landing procedure, including the type of landing surface and appropriate approach and glide air speeds, shall be specified in the operating procedures section of the Rotorcraft Flight Manual. (See §§ 6.740 and 6.742.)

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

(b) The approach and landing shall be made with power off for single-engine

rotorcraft, and with one engine inoperative for multiengine rotorcraft.

(c) The approach and landing shall be entered from steady autorotation and shall be made in such a manner that its reproduction would not require an exceptional degree of skill 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 loop, porpoise, or water loop.

§ 6.115 *Power-off landings for multiengine rotorcraft.* For all multiengine rotorcraft it shall be possible to make a safe landing following complete failure of all power during normal operating conditions.

FLIGHT CHARACTERISTICS

§ 6.120 *General.* (a) The rotorcraft shall comply with the requirements prescribed in §§ 6.120 through 6.123 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) For night or instrument certification the rotorcraft shall have such additional flight characteristics as the Administrator finds are required for safe operation under those conditions.

§ 6.121 *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 § 6.711) 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 weight and 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.

§ 6.122 *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.

§ 6.123 *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 1.1 V_{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 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

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

§ 6.131 *Ground resonance.* There shall be no uncontrollable tendency for the rotorcraft to oscillate when the rotor is turning and the rotorcraft is on the ground.

§ 6.132 *Spray characteristics.* For rotorcraft equipped with floats, the spray characteristics during taxying, take-off, and landing shall be such as not to obscure the vision of the pilot nor produce damage to the rotors, propellers, or other parts of the rotorcraft.

MISCELLANEOUS FLIGHT REQUIREMENTS

§ 6.140 *Flutter and vibration.* All parts of the rotorcraft shall be demonstrated to be free from flutter and excessive vibration under all speed and power conditions appropriate to the operation of the type of rotorcraft. (See also §§ 6.203 (f) and 6.711.)

SUBPART C—STRUCTURE

GENERAL

§ 6.200 *Loads.* (a) Strength requirements of this subpart are specified in terms of limit and ultimate loads. Unless otherwise stated, the specified loads shall be considered as limit loads. In determining compliance with these requirements the provisions set 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, unless its application to the resulting internal stresses is more conservative.

(c) Unless otherwise provided, the specified air, ground, and 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 conditions.

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

§ 6.201 *Strength and deformation.* (a) The structure shall 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.

§ 6.202 *Proof of structure.* (a) Proof of compliance of the structure with the strength and deformation requirements of § 6.201 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 § 6.203.

§ 6.203 *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 § 6.412).

(b) Control surface and system limit load tests (see § 6.323).

(c) Control system operation tests (see § 6.324).

(d) Flight stress measurements (see §§ 6.221 and 6.250).

(e) Landing gear drop tests (see § 6.237).

(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.

§ 6.204 *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 design weight.

(b) Power-on and power-off main rotor rpm ranges (see §§ 6.103 and 6.713 through 6.714 (b)).

(c) Maximum forward speeds for the power-on and power-off rotor rpm ranges established in accordance with paragraph (b) of this section (see § 6.711).

(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

§ 6.210 *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 § 6.741.)

§ 6.211 *Flight load factors.* The flight load factors shall represent rotor load factors. The net load factor acting at the center of gravity of the rotorcraft shall be obtained by proper consideration of balancing loads acting in the specific flight conditions.

§ 6.212 *Maneuvering conditions.* The rotorcraft structure shall be designed for a positive maneuvering limit load factor of 3.5 and for a negative maneuvering limit load factor of 1.0, except that lesser values shall be allowed if the manufacturer shows by analytical study and flight demonstrations that the probability of exceeding the values selected is extremely remote. In no case shall the limit load factors be less than 2.0 positive and 0.5 negative. The resultant loads shall be assumed to be applied at the center(s) of the rotor hub(s) and to act in such directions 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.

§ 6.213 *Gust conditions.* The rotorcraft structure shall be designed to withstand the loading due to a vertical gust of 30 fps in velocity in conjunction with the critical rotorplane air speeds, including hovering.

CONTROL SURFACE AND SYSTEM LOADS

§ 6.220 *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 §§ 6.221 through 6.225.

§ 6.221 *Auxiliary rotor assemblies.* Auxiliary rotor assemblies shall be tested in accordance with the provisions of § 6.412 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.

§ 6.222 *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.

§ 6.223 *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.

§ 6.224 *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.

§ 6.225 *Primary control systems.* Manual control systems shall comply with the provisions of paragraphs (a) and (b) of this section.

(a) From the pilot compartment to the stops which limit the range of motion of the pilots' controls, the controls shall be designed to withstand the limit pilot applied forces as set forth in subparagraphs (1) through (3) of this paragraph, unless it is shown that the pilot is unable to apply such loads to the system. In the latter event the system shall be designed for the maximum loads which the pilot is able to apply, except that in any case values less than 0.60 of those specified shall not be employed.

(1) Foot type controls—130 pounds.

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

(3) Wheel type controls—fore and aft 100 pounds—laterally 53-pound couple applied on opposite sides of the control wheel.

(b) From the stops to the attachment of the control system to the rotor blades (or control areas) the control system shall be designed to withstand the maximum loads which can be obtained in normal operation of the rotorcraft, except that where jamming, ground gusts, control inertia, or friction can cause loads exceeding operational loads, the system shall be capable of supporting without yielding 0.60 of the loads specified in paragraph (a) (1), (2), and (3) of this section.

LANDING LOADS

§ 6.230 *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 one-half 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 § 6.237, except in conditions in which other values of load factor 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 §§ 6.231 through 6.236 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.

§ 6.231 *Level landing conditions.* (a) Under loading conditions prescribed in paragraph (b) 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 while 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 § 6.230.

(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.

§ 6.232 *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.

§ 6.233 *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 § 6.231 (b) (1). The unbalanced external loads shall be reacted by the inertia of the rotorcraft.

§ 6.234 *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 § 6.231 (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.

§ 6.235 *Brake roll conditions.* The rotorcraft attitudes shall be assumed to be the same as those prescribed for the level landing conditions in § 6.231 (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.

§ 6.236 *Taxying 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.

§ 6.237 *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 § 6.230 (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 § 6.230 (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:

$$W_e = W\left[\frac{h+(1-L)d}{h+d}\right]; \text{ and } n = n_j\frac{W_e}{W}+L;$$

where:

W_e = the effective weight to be used in the drop test (pounds);

$W = W_M$ 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 a main gear static reaction, taking into consideration the distance between the direction of the main wheel reaction and the aircraft center of gravity;

$W = W_N$ for nose gear units (pounds), equal to the vertical component of the static 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 1.0g downward and 0.25g 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);

n = limit inertia load factor;

n_j = the load factor during impact developed on the mass used in the drop test (i. e., the acceleration dv/dt in g's recorded in the drop test plus 1.0).

(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.

§ 6.240 *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 § 6.230 (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 bearings. (For P see subparagraph (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 through the center line of the pedestal bearings. (For P and n see subparagraph (a) (1) of this section.)

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

(a) *Up load conditions.* (1) With the rotorcraft assumed in the static level attitude a load shall be applied so that the resultant water reaction passes vertically through the center of gravity of the rotorcraft. The limit load factor shall be determined in accordance with § 6.230 (d), or shall be assumed to be the same as the load factor determined for the ground type landing gear.

(2) The vertical load prescribed in subparagraph (1) of this paragraph shall be applied together with an aft component equal to 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 total side component shall be equal to 0.25 the total vertical load in this condition and shall be applied to one float only.

MAIN COMPONENT REQUIREMENTS

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

(a) The hubs, blades, blade attachments, and blade controls which are subject to alternating stresses shall be designed to withstand repeated loading conditions. 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 § 6.204. The service life of such parts shall be established by the applicant on the basis of fatigue tests or by other methods found acceptable to the Administrator.

(b) The main rotor structure shall be designed to withstand the critical flight loads prescribed in §§ 6.210 through 6.213.

(c) The main rotor structure shall be designed to withstand the limit loads prescribed in §§ 6.210 through 6.213 under conditions of autorotation necessary for normal operation. The rotor rpm used shall be such as to include the effects of altitude.

(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 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 § 6.251 (c). The design torque shall be distributed to the rotor blades in a rational manner.

§ 6.251 *Fuselage, landing gear, and rotor pylon structure.* The requirements of paragraphs (a) through (d) of this section shall apply to the fuselage, landing gear, and rotor pylon structure.

(a) The structure shall be designed to withstand the critical loads prescribed in §§ 6.210 through 6.213. It shall be permissible to represent the resultant rotor force as a single force applied at the hub attachment point. The balancing and inertia loads occurring under the accelerated flight conditions as well as the thrust from auxiliary rotors shall be considered.

(b) The structure shall be designed to withstand the applicable ground loads prescribed in §§ 6.230 through 6.245.

(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 § 6.1 (g) (3), by a factor of 1.33. For 4-, 3-, and 2-cylinder engines the factor shall be 2, 3, and 4, respectively.

(d) The structure shall be designed to withstand the loads prescribed in § 6.250 (d) and (f).

EMERGENCY LANDING CONDITIONS

§ 6.260 *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 § 6.355), 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.

SUBPART D—DESIGN AND CONSTRUCTION

GENERAL

§ 6.300 *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.

§ 6.301 *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.

§ 6.302 *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 an approved process specification.

§ 6.303 *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.

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

(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 precautions shall be taken against corrosion from salt water, particularly where parts made from different metals are in close proximity.

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

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

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

(c) ANC-5, ANC-18, and ANC-23, Part II values shall be 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 disastrous fatigue failure.

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

§ 6.307 *Special factors*—(a) *General.* Where there is uncertainty concerning the actual strength of a particular part of the 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 § 6.200 (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

§ 6.310 *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.

§ 6.311 *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.

§ 6.312 *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.

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

CONTROL SYSTEMS

§ 6.320 *General.* All controls and control systems shall operate with ease, smoothness, and positiveness appropriate to their function. (See also §§ 6.350 and 6.353.)

§ 6.321 *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.

§ 6.322 *Control system 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) A means shall be provided to give unmistakable warning to the pilot when the locking device is engaged.

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

§ 6.323 *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) Analyses or individual load tests shall be conducted to demonstrate compliance with the special factor requirements for control system joints subjected to angular motion. (See §§ 6.307 and 6.325.)

§ 6.324 *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.

§ 6.325 *Control system details.* 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.

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

§ 6.327 *Autorotation 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.

LANDING GEAR

§ 6.335 *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.

§ 6.336 *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.

§ 6.337 *Tires.* Landing gear wheels shall be equipped with any make or type of tire provided that the tire is a proper fit on the rim of the wheel and provided that the approved tire rating is not exceeded. The maximum static load rating of the tire shall not be less than the static ground reaction obtained at the wheel, assuming the maximum design weight concentrated at the most unfavorable center of gravity position.

§ 6.338 *Skis.* The maximum limit load rating of each ski shall not be less than the maximum limit load determined in accordance with the applicable ground load requirements of this part.

FLOATS

§ 6.340 *General.* The requirements of §§ 6.341 and 6.342 shall apply to the design of floats.

§ 6.341 *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 4 watertight compartments of approximately equal volume.

§ 6.342 *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 the maximum altitude for which certification with floats is sought. In addition, the float shall withstand the vertical loads prescribed in § 6.245 (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 § 6.245. The loads specified may be distributed along the length of the floats.

PERSONNEL AND CARGO ACCOMMODATIONS

§ 6.350 *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) Vibration and noise characteristics of cockpit appurtenances shall not interfere with the safe operation of the rotorcraft.

§ 6.351 *Pilot compartment vision.* The pilot compartment shall be arranged to afford the pilot a sufficiently extensive, clear, and undistorted view for the safe operation of the rotorcraft. During flight in a moderate rain condition the pilot shall have an adequate view of the flight path in normal flight and landing, and have sufficient protection from the elements so that his vision is not unduly impaired. The pilot compartment shall be free of glare and reflections which would interfere with the pilot's vision. For rotorcraft intended for night operation, the demonstration of these qualities shall include night flight tests.

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

§ 6.353 *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 § 6.737.)

(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.

§ 6.354 *Doors.* Closed cabins shall be provided with at least one adequate and easily accessible external door. No passenger door shall be so located with respect to the rotor discs as to endanger persons using the door.

§ 6.355 *Seats and berths.* On rotorcraft, manufactured on or after the effective date of this part (January 15, 1951), all seats and berths, including their supporting structure, shall be designed for the loads resulting from all specified flight and landing conditions, including the emergency landing conditions of § 6.260. Reactions from safety belts and harnesses shall be taken into account. In addition, pilot seats shall be designed for the reactions resulting from the application of pilot forces to the flight controls as prescribed in § 6.225 (a). (See § 6.101 (b) (4) for weight of occupants.)

§ 6.356 *Cargo and baggage compartments.* (See also § 6.382.) (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 § 6.260.

(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.

§ 6.357 *Emergency exits.* (a) Closed cabins on rotorcraft carrying more than 5 persons shall be provided with an emergency exit. Additional exits shall be provided where the total seating capacity is more than 15. The provisions of subparagraphs (1) through (6) of this paragraph shall apply. (See also § 6.738 (c).)

(1) An emergency exit shall consist of a movable window or panel or of an additional external door which provides a clear and unobstructed opening, the minimum dimensions of which shall be such that a 19 inch by 26 inch ellipse may be completely inscribed therein.

(2) An emergency exit shall be readily accessible, shall not require exceptional agility of a person using it, and shall be so located as to facilitate egress without crowding in all probable attitudes in which the rotorcraft may be after a crash.

(3) The method of opening an emergency exit shall be simple and obvious and the exit shall be so arranged and marked as to be readily located and operated even in darkness.

(4) Reasonable provisions shall be made against the jamming of emergency exits as a result of fuselage deformation.

(5) At least one emergency exit shall be on the opposite side of the cabin from the main door.

(6) The proper functioning of emergency exits shall be demonstrated by tests.

§ 6.358 *Ventilation.* The ventilating system for the pilot and passenger compartments shall be so designed as to preclude the presence of excessive quantities of fuel fumes and carbon monoxide. The concentration of carbon monoxide shall not exceed 1 part in 20,000 parts of air under conditions of forward flight or hovering in zero wind. For other conditions of operation, if the carbon monoxide concentration exceeds this value, suitable operating restrictions shall be provided.

FIRE PREVENTION

§ 6.380 *General.* The fire prevention requirements of this subpart apply to personnel and cargo compartments. Additional fire prevention requirements are prescribed in Subpart E, Powerplant Installation, and Subpart F, Equipment.

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

§ 6.382 *Cargo and baggage compartments.* Cargo and baggage compartments shall be constructed of or completely lined with fire-resistant material, except that flame-resistant materials shall be acceptable in compartments which are readily accessible to a crew member in flight. Compartments shall include no controls, wiring, lines, equipment, or accessories the damage or failure of which would affect the safe operation of the rotorcraft, unless such items are shielded, isolated, or otherwise protected so that they cannot be damaged by movement of cargo in the compartment, and so that any breakage or failure of such items will not create a fire hazard.

§ 6.383 *Heating systems*—(a) *General.* Heating systems involving the passage of cabin air over or in close proximity to the exhaust manifold shall not be used unless precautions are incorporated in the design to prevent the introduction of carbon monoxide into the cabin or pilot compartment.

(b) *Heat exchangers.* Heat exchangers shall be constructed of suitable materials, shall be cooled adequately under all conditions, and shall be capable of easy disassembly for inspection.

(c) *Combustion heaters.* Gasoline-operated combustion heaters shall be of an approved type and shall be installed so as to comply with the applicable sections of the powerplant installation requirements covering fire hazards and precautions. All applicable requirements concerning fuel tanks, lines, and exhaust systems shall be considered. (See §§ 6.422 through 6.428 and 6.463.)

§ 6.384 *Fire protection of structure, controls, and other parts.* All structure, controls, rotor mechanism, and other parts essential to a controlled landing of the rotorcraft which would be affected by powerplant fires shall either 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 power-

plant fire conditions. (See also §§ 6.480 and 6.483 (a).)

MISCELLANEOUS

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

§ 6.391 *Ballast provisions.* Ballast provisions shall be so designed and constructed as to prevent the inadvertent shifting of the ballast in flight. (See also §§ 6.105, 6.738, and 6.741 (c).)

SUBPART E—POWERPLANT INSTALLATION

GENERAL

§ 6.400 *Scope and general design.* (a) 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 §§ 6.604 and 6.613 for instrument installation and marking.) The general provisions of paragraphs (b) through (d) of this section shall be applicable.

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

(c) Accessibility shall be provided to permit such inspection and maintenance as is necessary to assure continued airworthiness.

(d) Electrical interconnections shall be provided to prevent the existence of differences of potential between major components of the powerplant installation and other portions of the rotorcraft.

§ 6.401 *Engine-type certification.* All engines shall be type certificated in accordance with the provisions of Part 13 of this subchapter.

§ 6.402 *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. It shall also be demonstrated that no portion of the rotor drive system is subjected to excessive vibratory stresses.

ROTOR DRIVE SYSTEM

§ 6.410 *Rotor drive mechanism.* The rotor drive mechanism shall incorporate a unit which will automatically disengage the engine from the main and auxiliary rotors in the event of power failure. The rotor drive mechanism 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. If a torque limiting device is employed in the rotor drive system (see § 6.250 (f)), such device shall be located to permit continued control of the rotorcraft after it becomes operative.

§ 6.411 *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.

§ 6.412 *Rotor drive and control mechanism endurance tests.* (a) The rotor drive and control mechanism shall be tested for not less than 100 hours. The test shall be conducted on the rotorcraft, and the power shall be absorbed by the actual rotors to be installed, except that the use of other ground or flight test facilities with any other appropriate method of power absorption shall be acceptable provided that all conditions of support and vibration closely simulate the conditions which would exist during a test on the actual rotorcraft. The endurance tests shall include the tests prescribed in paragraphs (b) through (g) of this section. At the conclusion of the endurance testing, all parts shall be in a serviceable condition.

(b) A 60-hour portion of the endurance test shall be run at not less than the maximum continuous engine speed in conjunction with maximum continuous engine power. In this test the main rotor shall be set in the position which will give maximum longitudinal cyclic pitch change to simulate forward flight. The auxiliary rotor controls shall be in the position for normal operation under the conditions of the test.

(c) A 30-hour portion of the endurance test shall be run at not less than 90 percent of maximum continuous engine speed and 75 percent of maximum continuous engine power. The main and auxiliary rotor controls during this test shall be in the position for normal operation under the conditions of the test.

(d) A 10-hour portion of the endurance test shall be run at not less than take-off engine power and speed. The main and auxiliary rotor controls shall be in the normal position for vertical ascent during this test.

(e) The portions of the endurance test prescribed in paragraphs (b) and (c) of this section shall be conducted in intervals of not less than 30 minutes and may be accomplished either on the ground or in flight. The portion of the endurance test prescribed in paragraph (d) of this section may be conducted in intervals of 5 minutes or more.

(f) At intervals of not more than every 5 hours during the endurance tests prescribed in paragraphs (b), (c), and (d) of this section the engine shall be stopped rapidly enough to allow the engine and rotor drive to be automatically disengaged from the rotors.

(g) There shall be accomplished under the operating conditions specified in paragraph (b) of this section 500 complete cycles of lateral control and 500 complete cycles of longitudinal control of the main rotors, and 500 complete cycles of control of all auxiliary rotors. A complete control cycle shall be considered to involve movement of the controls from the neutral position, through both extreme positions, and back to the neutral position, except that control movement need not produce loads or flapping motions exceeding the maximum loads or motions encountered in flight. The control cycling may be accomplished during the testing prescribed in paragraph (b) of this section or may be accomplished separately.

§ 6.413 *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.

§ 6.414 *Shafting critical speed.* The critical speeds of all shafting shall be determined by actual demonstration, except that analytical methods shall be acceptable for determining these speeds if the Administrator finds that reliable methods of analysis are available for the particular design. If the critical speeds lie within or close to the operating ranges for idling, power-on, and autorotative conditions, it shall be demonstrated by tests that the resultant stresses are within safe limits. If analytical methods are used and indicate that no critical speeds lie within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the permissible operating ranges shall be adequate to allow for possible variations of the computed values from actual values.

§ 6.415 *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

§ 6.420 *Capacity and feed.* The fuel supply system shall be arranged so that, in so far as practicable, the entire fuel supply can be utilized in the maximum inclinations of the fuselage 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 (see § 6.422 (e)) the system shall feed fuel promptly after one tank is turned off and another tank is turned on, and there shall be installed in addition to the fuel quantity indicator (see § 6.604 (a) (1)) a warning device to indicate 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 supply with the rotorcraft in the most critical sustained flight attitude.

§ 6.421 *Unusable fuel supply.* The unusable fuel supply in each tank shall be that quantity at which the first evidence of malfunctioning occurs in any sustained flight condition at the most critical weight and center of gravity position within the approved limitations. The

unusable fuel supply shall be determined for each tank used in normal operation. (See also §§ 6.104, 6.736, and 6.741 (g).)

§ 6.422 *Fuel tank construction and installation.* Fuel tanks shall be designed and installed in accordance with the provisions of paragraphs (a) through (e) of this section.

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

(b) Fuel tanks shall be capable of withstanding, without failure or leakage, an internal pressure equal to the pressure developed during the maximum limit acceleration with full tanks, except that in no case shall the minimum internal pressure be less than 3.5 lb./sq. in. for conventional type tanks or less than 2.0 lb./sq. in. for bladder type tanks.

(c) Fuel tanks of 10 gallons or greater capacity shall incorporate internal baffles unless external support is provided to resist surging.

(d) Fuel tanks shall be separated from the engine compartment by a fire wall. At least one-half inch clear air space shall be provided between the tank and fire wall.

(e) Spaces adjacent to the surfaces of fuel tanks shall be ventilated so that fumes cannot accumulate in the tank compartment in case of leakage. If two or more tanks have their outlets interconnected, they shall be considered as one tank. The air spaces in such tanks shall be interconnected to prevent the flow of fuel from one tank to another as a result of a difference in pressure in the respective tank air spaces.

§ 6.423 *Fuel tank details*—(a) *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.

(b) *Sump.* Each fuel tank shall incorporate a sump and drain located at the point in the tank which is the lowest when the rotorcraft is in the normal ground attitude. The main fuel supply shall not be drawn from the bottom of the sump.

(c) *Filler connection.* The design of fuel tank filler connections shall be such as to prevent the entrance of fuel into the fuel tank compartment or to any other portion of the rotorcraft other than the tank itself. (See also § 6.738 (b) (1).)

(d) *Vents.* 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 air vents shall be arranged to minimize the possibility of stoppage by dirt or ice formation.

(e) *Outlet.* Fuel tank outlets shall be provided with large-mesh finger strainers.

§ 6.424 *Fuel pumps.* If a mechanical pump is employed, an emergency pump shall also be installed to be available for immediate use in case of failure of the mechanical pump. Pumps of appropriate capacity may also be used for pumping fuel from an auxiliary tank to a main fuel tank. Mechanical pump systems shall be so arranged that they cannot feed from more than one tank at a time.

§ 6.425 *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 and due to 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 hose shall be of an approved type.

(d) All fuel lines and fittings shall be of sufficient size so that the fuel flow, with the fuel being supplied to the carburetor at the minimum pressure for proper carburetor operation, is not less than the following:

(1) For gravity feed systems: 1.5 times the normal flow required to operate the engine at take-off power;

(2) For pump systems: 1.25 times the normal flow required to operate the engine at take-off power.

(e) Design factors conducive to vapor lock, such as vertical humps in the lines, shall be avoided.

(f) A test for proof of compliance with the applicable flow requirements shall be conducted.

§ 6.426 *Valves.* A positive and quick-acting valve which will shut off all fuel to each engine individually shall be provided. The control for this valve shall be within easy reach of appropriate flight personnel. In the case of rotorcraft employing more than one source of fuel supply, provision shall be made for independent feeding from each source. The shutoff valve shall not be located closer to the engine than the remote side of the fire wall.

§ 6.427 *Strainers.* 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 position. The screen shall be easily removable for cleaning. If an engine-driven fuel pump is provided, the strainer shall be located between the fuel tank and the pump.

§ 6.428 *Drains.* One or more accessible drains shall be provided at the lowest point in the fuel system to drain completely all parts of the system when the rotorcraft is in its normal position on level ground. Such drains shall discharge clear of all parts of the rotorcraft and shall be equipped with safety locks to prevent accidental opening.

§ 6.429 *Fuel quantity indicator.* The fuel quantity indicator (see § 6.613 (b)) shall be installed to indicate clearly to the flight crew the quantity of fuel in each tank while in flight. When two or more tanks are closely interconnected by a gravity feed system and vented, and when it is impossible to feed from each tank separately, only one fuel quantity indicator need be installed. If exposed sight gauges are employed they shall be installed and guarded to preclude the possibility of breakage or damage.

OIL SYSTEM

§ 6.440 *General.* (a) Each engine shall be provided with an independent oil system capable of supplying the engine with an appropriate quantity of oil at a temperature not exceeding the maximum which has been established as safe for continuous operation. (For oil system instruments see §§ 6.604 and 6.735.)

(b) The usable oil capacity shall not be less than the product of the endurance of the rotorcraft under critical operating conditions and the maximum oil consumption of the engine under the same conditions, to which product a suitable margin shall be added to assure adequate circulation and cooling of the oil system. In lieu of a rational analysis of rotorcraft endurance and oil consumption, the usable oil capacity of 1 gallon for each 40 gallons of usable fuel quantity shall be considered acceptable. (See also § 6.101 (d) (3).)

(c) The ability of the oil cooling provisions to maintain the oil inlet temperature to the engine at or below the maximum established value shall be demonstrated by flight tests.

§ 6.441 *Oil tank construction and installation.* Oil tanks shall be designed and installed in accordance with the provisions of paragraphs (a) through (e) of this section.

(a) Oil tanks shall be capable of withstanding without failure all vibration, inertia, fluid, and structural loads to which they may be subjected in operation.

(b) Oil tanks shall be capable of withstanding without failure or leakage an internal pressure of 5 lb./sq. in.

(c) Oil tanks shall be provided with an expansion space of not less than 10 percent of the tank capacity, nor less than one-half gallon.

(d) Oil tanks shall be vented.

(e) Provision shall be made in the filler opening to prevent oil overflow from entering the compartment in which the oil tank is located. (See also § 6.738 (b) (2).)

§ 6.442 *Oil lines and fittings.* (a) Oil lines shall be supported to prevent excessive vibration.

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

(c) Flexible hose shall be of an approved type.

(d) Oil lines shall have an inside diameter not less than the inside diameter of the engine inlet or outlet, and shall have no splices between connections.

§ 6.443 *Oil drains.* One or more accessible drains shall be provided at the lowest point in the oil system to drain completely all parts of the system when the rotorcraft is in its normal position on level ground. Such drains shall discharge clear of all parts of the rotorcraft and shall be equipped with safety locks to prevent accidental opening.

§ 6.444 *Oil quantity gauge.* An oil quantity indicator (see § 6.735) shall be installed to indicate during the filling

operation the amount of oil in the oil tank.

§ 6.445 *Oil temperature indication.* A means shall be provided for measuring during flight the oil temperature at the engine inlet. If a separate oil system is provided for the main rotor drive, a means shall also be provided to give a warning in flight when the oil temperature has exceeded a safe value. (See § 6.604.)

§ 6.446 *Oil pressure indication.* If the main rotor drive incorporates an independent oil pressure system, a means shall be provided to give a warning in flight when the oil pressure has fallen below a safe value.

COOLING SYSTEM

§ 6.450 *General.* The cooling system shall be capable of maintaining engine temperatures within safe operating limits under all conditions of flight during a period at least equal to that established by the fuel capacity of the rotorcraft, assuming normal engine power and speeds.

§ 6.451 *Cooling tests.* Compliance with the provisions of § 6.450 shall be demonstrated in flight tests in which engine temperature measurements are obtained under critical flight conditions. Such tests shall be conducted in air at temperatures corresponding with the maximum anticipated air temperatures as specified in paragraph (a) of this section. If the tests are conducted under conditions which deviate from the maximum anticipated air temperature, the recorded powerplant temperatures shall be corrected in accordance with the provisions of paragraphs (b) and (c) 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 engines involved, and the mixture settings shall be those used in normal operation.

(a) *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.

(b) *Correction factor for cylinder head and oil inlet temperatures.* The cylinder head and oil inlet 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 cylinder head or oil inlet temperature recorded during the cooling test, unless a more rational correction is shown to be applicable.

(c) *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.

INDUCTION AND EXHAUST SYSTEMS

§ 6.460 *General.* The induction and exhaust systems shall be designed in accordance with accepted practice.

§ 6.461 *Air induction.* (a) The engine air induction system shall be designed to supply the proper quantity of air to the engine under all conditions of operation.

(b) Cold air intakes shall open completely outside the cowling unless the emergence of backfire flames is positively prevented.

(c) Carburetor air intakes shall be provided with drains. The drains shall not discharge fuel in the possible path of exhaust flames.

§ 6.462 *Induction system de-icing and anti-icing provisions.* (a) The engine air induction system shall incorporate means for the prevention and elimination of ice accumulations. Unless it is demonstrated that this can be accomplished by other means, compliance with the following heat rise provisions shall be demonstrated in air free of visible moisture at a temperature of 30° F. when the engine is operating at 75 percent of its maximum continuous power.

(b) Rotorcraft equipped with sea level engines employing conventional venturi carburetors shall have a preheater capable of providing a heat rise of 90° F.

(c) Rotorcraft equipped with sea level engines employing carburetors which embody features tending to reduce the possibility of ice formation shall be provided with a sheltered alternate source of air. The preheat supplied to this alternate air intake shall be not less than that provided by the engine cooling air downstream of the cylinders.

(d) Rotorcraft equipped with altitude engines employing conventional venturi carburetors shall have a preheater capable of providing a heat rise of 120° F.

(e) 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., except that if a fluid deicing system is used the heat rise need not be greater than 40° F.

§ 6.463 *Exhaust manifolds.* (See also § 6.383.) (a) Exhaust manifolds shall be designed to provide for expansion, and shall be arranged and cooled so that local hot points cannot form.

(b) Exhaust manifolds shall be installed in accordance with the provisions of subparagraphs (1) through (3) of this paragraph:

(1) Exhaust manifolding shall be such that exhaust gases are discharged clear of cowling, rotorcraft structure, carburetor air intake, and fuel system parts or drains.

(2) Exhaust manifolding shall not be located immediately adjacent to or under the carburetor or fuel system parts unless such parts are protected against leakage.

(3) Exhaust manifolding shall be such that exhaust gases do not discharge in a manner which would impair pilot vision at night due to glare.

POWERPLANT CONTROLS AND ACCESSORIES

§ 6.470 *Powerplant controls; general.* The provisions of § 6.353 shall be applicable to all powerplant controls with respect to location and arrangement, and the provisions of § 6.737 shall be applicable to all powerplant controls with respect to marking. All flexible powerplant controls shall be of an approved type.

§ 6.471 *Throttle 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.

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

§ 6.472 *Ignition switches.* (a) Means shall be provided for quickly shutting off all ignition by the grouping of switches or by providing a master ignition control.

(b) If a master ignition control is provided, a guard shall be incorporated to prevent inadvertent operation of the control.

§ 6.473 *Mixture controls.* 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.

§ 6.474 *Powerplant accessories.* 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.

POWERPLANT FIRE PROTECTION

§ 6.480 *General.* The powerplant installation shall be protected against fire in accordance with §§ 6.481 through 6.484. Additional fire prevention requirements are prescribed in Subpart D, Design and Construction, and Subpart F, Equipment.

NOTE: The powerplant fire protection provisions are intended to insure that the main and auxiliary rotors and controls remain operable, 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 autorotational landing.

§ 6.481 *Ventilation.* Compartments which include powerplant installation shall have provision for ventilation.

§ 6.482 *Shutoff means.* Means shall be provided to shut off the flow in all lines carrying flammable fluids into the engine compartment, except that a shutoff means need not be provided in lines forming an integral part of an engine. 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. Shutoff valves and their controls shall be located on the remote side of the fire wall from the engine, unless it is shown

that the valve will perform its intended functions under all fire conditions likely to result from an engine fire. In installations using engines of less than 500 cu. in. displacement, shutoff means need not be provided for engine oil systems.

§ 6.483 *Fire wall.* (a) Engines shall be isolated from personnel compartments by means of fire walls, shrouds, or other equivalent means. They shall be similarly isolated from the structure, controls, rotor mechanism, and other parts essential to a controlled landing of the rotorcraft, unless such parts are protected in accordance with the provisions of § 6.384. All auxiliary power units, fuel-burning heaters, and other combustion equipment which are intended for operation in flight shall be isolated from the remainder of the rotorcraft by means of fire walls, shrouds, or other equivalent means. In complying with the provisions of this paragraph, account shall be taken of the probable path of a fire as affected by the air flow in normal flight and in autorotation. (See also § 6.486.)

(b) Fire walls and shrouds shall be constructed in such a manner that no hazardous quantity of air, fluids, or flame can pass from the engine compartment to other portions of the rotorcraft.

(c) All openings in the fire wall or shroud shall be sealed with close fitting fireproof grommets, bushings, or firewall fittings.

(d) Fire walls and shrouds shall be constructed of fireproof material and shall be protected against corrosion.

§ 6.484 *Engine cowling and engine compartment covering.* (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) Provision shall be made to permit rapid and complete drainage of all portions of the cowling or engine compartment in all normal ground and flight attitudes. Drains shall not discharge in locations which might cause a fire hazard.

(c) Cowling or engine compartment covering shall be constructed of fireresistant material.

(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.

§ 6.485 *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 fireresistant 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 fireresistant 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.

§ 6.486 *Flammable fluids.* (a) Fuel tanks shall be isolated from the engine by a fire wall or shroud. On all rotorcraft having engines of more than 900 cu. in. displacement, oil tanks and other flammable fluid tanks shall be similarly isolated unless the fluid contained, the design of the system, the materials used in the tank, the shutoff means, all connections, lines, and controls are such as to provide an equally high degree of safety.

(b) Not less than one-half inch of clear air space shall be provided between any tank and the isolating fire wall or shroud, unless other equivalent means are used to protect against heat transfer from the engine compartment to the flammable fluid.

SUBPART F—EQUIPMENT

GENERAL

§ 6.600 *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.

§ 6.601 *Functional and installational requirements.* Each item of equipment installed in a rotorcraft shall be:

(a) Of a type and 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.

§ 6.602 *Required basic equipment.* The equipment listed in §§ 6.603 through 6.605 shall be the required basic equipment. (See § 6.600.)

§ 6.603 *Flight and navigational instruments.* (See § 6.612 for installation requirements.) There shall be installed:

(a) An air-speed indicator. (See § 6.612 (a).)

(b) An altimeter.

(c) A magnetic direction indicator. (See § 6.612 (c).)

§ 6.604 *Powerplant instruments.* (See § 6.613 for installation requirements.)

(a) For each engine or tank there shall be installed:

(1) A fuel quantity indicator. (See § 6.613 (b).)

(2) An oil pressure indicator.

(3) An oil temperature indicator. (See § 6.613 (g).)

(4) A tachometer to indicate engine rpm and rotor rpm for the main rotor, or for each main rotor the speed of which can vary appreciably with respect to another main rotor.

(b) For each engine or tank (if required in reference section) there shall be installed:

(1) A cylinder head temperature indicator. (See § 6.613 (e).)

(2) A fuel pressure indicator (if pump-fed engines are used).

(3) A manifold pressure indicator (if altitude engines are used).

(4) An oil quantity indicator. (See § 6.613 (d).)

(c) For each transmission or gear box having an independent oil system there shall be installed:

(1) An oil temperature indicator, and

(2) An oil pressure indicator if a pressure system is employed.

§ 6.605 *Miscellaneous equipment.* There shall be installed:

(a) Approved seats for all occupants. (See § 6.355.)

(b) Approved safety belts for all occupants. (See § 6.643.)

(c) A master switch arrangement. (See §§ 6.623 and 6.624.)

(d) A source(s) of electrical energy (see §§ 6.620 through 6.622) where such electrical energy is necessary for operation of the rotorcraft.

(e) Electrical protective devices. (See § 6.625.)

INSTRUMENTS; INSTALLATION

§ 6.610 *General.* The provisions of §§ 6.611 through 6.613 shall apply to the installation of instruments in rotorcraft.

§ 6.611 *Arrangement and visibility of instrument installations.* (a) Flight, navigation, and powerplant instruments for use by each pilot shall be easily visible to him.

(b) On multiengine rotorcraft, identical powerplant instruments for the several engines shall be so located as to prevent any confusion as to the engines to which they relate.

(c) The vibration characteristics of the instrument panel shall be such as not to impair seriously the readability or the accuracy of the instruments or to damage them.

§ 6.612 *Flight and navigational instruments*—(a) *Air-speed indicating system.* The air-speed indicating system shall be so installed that the air-speed indicator shall indicate true air speed at sea level under standard conditions to within an allowable installational error of not more than plus or minus 3 percent of the calibrated air speed or 5 mph, whichever is greater. The calibration shall be made in flight at all forward speeds of 10 mph or over. The allowable installation error shall not be exceeded at any forward speed of 20 mph and over. (See § 6.732.)

(b) *Static air-vent system.* All instruments provided with static air case connections shall be so vented that the influence of rotorcraft speed, the opening and closing of windows, air-flow variation, moisture, or other foreign matter will not seriously affect their accuracy.

(c) *Magnetic direction indicator.* The magnetic direction indicator shall be so installed that its accuracy shall not be excessively affected by the rotorcraft's

vibration or magnetic fields. After the direction indicator has been compensated, the installation shall be such that the deviation in level flight does not exceed 10° on any heading. A suitable calibration placard shall be provided as specified in § 6.733.

§ 6.613 *Powerplant instruments*—(a) *Instrument lines.* Instrument lines shall comply with the provisions of § 6.425. In addition, instrument lines carrying flammable fluids or gases under pressure shall be provided with restricted orifices or equivalent safety devices at the source of the pressure to prevent the escape of excessive fluid or gas in case of line failure.

(b) *Fuel quantity indicator.* Fuel quantity indicators shall be calibrated to read zero during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply as defined by § 6.421. (See also § 6.736.)

(c) *Fuel flowmeter system.* When a flowmeter system is installed, the metering component shall include a means for by-passing the fuel supply in the event that malfunctioning of the metering component results in a severe restriction to fuel flow.

(d) *Oil quantity indicator.* (1) Means shall be provided to indicate the quantity of oil in each tank when the rotorcraft is on the ground. (See § 6.735.)

(2) If an oil transfer system or a reserve oil supply system is installed, means shall be provided to indicate to the crew during flight the quantity of oil in each tank.

(e) *Cylinder head temperature indicator.* A cylinder head temperature indicator shall be provided for each engine or rotorcraft equipped with cooling shutters. In the case of rotorcraft which do not have cooling shutters, an indicator shall be provided if compliance with the provisions of § 6.451 is demonstrated in a condition other than the most critical cooling flight condition.

(f) *Carburetor air temperature indicating system.* A carburetor air temperature indicating system shall be provided for each engine equipped with a preheater which is capable of providing a heat rise in excess of 60° F.

(g) *Oil temperature indicator.* Means shall be provided to indicate to the appropriate members of the flight crew, during flight, the oil inlet temperature of each engine.

(h) *Coolant temperature indicator.* Means shall be provided to indicate to the appropriate members of the flight crew, during flight, the coolant outlet temperature of each liquid-cooled engine.

ELECTRICAL SYSTEMS AND EQUIPMENT

§ 6.620 *Installation.* (a) Electrical systems and equipment shall be free from hazards in themselves, in their method of operation, and in their effects on other parts of the rotorcraft. They shall be protected from fuel, oil, water, other detrimental substances, and from mechanical damage.

(b) The design of all components of the electrical system shall be appropriate for the intended use, and the components shall be capable of satisfactory operation over the entire range of environmental conditions encountered in the operation of the rotorcraft.

(c) Electrical sources of power shall have sufficient capacity during all normal flight operating conditions to supply the electrical load requirements without electrical or thermal distress. For emergency operating conditions the capacity of electrical power sources shall be sufficient for all electrical loads necessary to permit a safe landing.

§ 6.621 *Batteries.* A battery or batteries shall be provided consistent with the needs of the electrical system in complying with the requirements of electrical power capacity. The installation shall provide adequate ventilation and drainage for the battery under all operating conditions, and means shall be provided to prevent corrosive battery substance from coming in contact with other parts of the rotorcraft during servicing or in flight.

§ 6.622 *Generator system*—(a) *Generator.* Sources of electrical power (including the battery) shall be designed to function coordinately, and shall also be capable of independent operation. The generator(s) shall be capable of delivering sufficient power to keep the batteries charged, and in addition shall provide for the normal electrical power requirements of the rotorcraft.

(b) *Generator controls.* Generator voltage control equipment shall be capable of regulating the generator output within rated limits.

(c) *Reverse current cut-off.* A generator reverse current cut-off shall disconnect the generator from the battery and from other generators when the generator is developing a voltage of such value that current sufficient to cause malfunctioning can flow into the generator.

§ 6.623 *Master switch.* A master switch arrangement shall be provided which will disconnect all sources of electrical power from the main distribution system at a point adjacent to the power sources.

§ 6.624 *Master switch installation.* The master switch or its controls shall be so installed that it is easily discernible and accessible to a member of the crew in flight.

§ 6.625 *Protective devices.* Protective devices (fuses or circuit breakers) shall be installed in the circuits to all electrical equipment, except that such items need not be installed in the main circuits of starter motors or in other circuits where no hazard is presented by their omission. If fuses are used, one spare of each rating or 50 percent spare fuses of each rating, whichever is the greater, shall be provided.

§ 6.626 *Protective devices installation.* Protective devices in circuits essential to safety in flight shall be conveniently located and properly identified to facilitate replacement of fuses or resetting of circuit breakers in flight.

§ 6.627 *Electric cables.* The electric cables used shall be in accordance with approved standards for aircraft electric cable of a slow-burning type. They shall have current-carrying capacity sufficient to deliver the necessary power to the items of equipment to which they are connected.

§ 6.628 *Switches.* Switches shall be capable of carrying their rated current. They shall be accessible to the crew and shall be labeled as to operation and the circuit controlled.

LIGHTS

§ 6.630 *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.

§ 6.631 *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.

§ 6.632 *Position light system installation*—(a) *General.* The provisions of §§ 6.632 through 6.635 shall be applicable to the position light system as a whole, and shall be complied with if a single circuit type system is installed. The single circuit system shall include the items specified in paragraphs (b) through (f) of this section.

NOTE: Requirements for dual circuit position light systems are contained in Part 4b of this subchapter.

(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 light.* The rear position light shall be a white light mounted as far aft as practicable. The light shall be of an approved type.

(d) *Circuit.* The two forward position lights and the rear position light shall constitute a single circuit.

(e) *Flasher.* If employed, an approved position light flasher for a single circuit system shall be installed. The flasher shall be such that the system is energized automatically at a rate of not less than 60 nor more than 120 flashes per minute with an on-off ratio between 2.5:1 and 1:1. Unless the flasher is of a fail-safe type, means shall be provided in the system to indicate to the pilot when there is a failure of the flasher and a further means shall be provided for turning the lights on steady in the event of such failure.

(f) *Light covers and color filters.* Light covers or color filters used shall be of noncombustible material and shall be constructed so that they will not change color or shape or suffer any appreciable loss of light transmission during normal use.

§ 6.633 *Position light system dihedral angles.* The forward and rear position lights as installed on the rotorcraft shall show unbroken light within dihedral angles specified in paragraphs (a) through (c) of this section.

(a) Dihedral angle *L* (left) shall be considered formed by two intersecting vertical planes, one parallel to the longitudinal axis of the rotorcraft and the other at 110° to the left of the first, when looking forward along the longitudinal axis.

(b) Dihedral angle *R* (right) shall be considered formed by two intersecting vertical planes, one parallel to the longitudinal axis 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.

§ 6.634 *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 paragraph (b) 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 6–1. (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 6–2, where I is the minimum intensity prescribed in Figure 6–1 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 6–3, except that higher intensities in the overlaps shall be acceptable with the use of main beam intensities substantially greater than the minima specified in Figures 6–1 and 6–2 if the overlap intensities in relation to the main beam intensities are such as not to affect adversely signal clarity.

Dihedral angle (light included)	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

FIGURE 6-1—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 6-2—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

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.

FIGURE 6-3—MAXIMUM INTENSITIES IN OVERLAPPING BEAMS OF FORWARD AND REAR POSITION LIGHTS

§ 6.635 *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,
"$y - y_c$" is not numerically greater than 0.01, y_c being the y coordinate of the Planckian radiator for which $x_c = x$.

§ 6.636 *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.

SAFETY EQUIPMENT

§ 6.640 *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 § 6.738 (e).)

§ 6.641 *Flares.* When parachute flares are installed, they shall be of an approved type, and their installation shall be in accordance with § 6.642.

§ 6.642 *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.

§ 6.643 *Safety belts.* Rotorcraft manufactured on or after the effective date of this part (January 15, 1951) shall be equipped with safety belts of an approved type. (See § 6.18.) In no case shall the rated strength of the safety belt be less than that corresponding with the ultimate load factors specified, taking due account of the dimensional characteristics of the safety belt installation for the specific seat or berth arrangement. Safety belts shall be attached so that no part of the anchorage will fail at a load lower than that corresponding with the ultimate load factors specified. (See § 6.260.)

§ 6.644 *Emergency flotation and signaling equipment.* When emergency flotation and signaling equipment is required by the operating rules of the regulations in this subchapter such equipment shall comply with the provisions of paragraphs (a) through (c) of this section.

(a) Rafts and life preservers shall be of an approved type and shall be so installed as to be readily available to the crew and passengers.

(b) Rafts released automatically or released by the pilot shall be attached to the rotorcraft by means of lines to keep them alongside the rotorcraft. The strength of the lines shall be such that they will break before submerging the empty raft.

(c) Signaling devices shall be free from hazard in their operation and shall be installed in an accessible location.

MISCELLANEOUS EQUIPMENT

§ 6.650 *Hydraulic systems*—(a) *Design.* Hydraulic systems and elements shall withstand, without exceeding the yield point, all structural loads which are expected to be imposed in addition to the hydraulic loads.

(b) *Tests.* Hydraulic systems shall be substantiated by proof pressure tests. When proof tested, no part of a hydraulic system shall fail, malfunction, or experience a permanent set. The proof load of any system shall be 1.5 times the

maximum operating pressure of that system.

(c) *Accumulators.* Hydraulic accumulators or pressurized reservoirs shall not be installed on the engine side of the fire wall, except when they form an integral part of the engine.

SUBPART G—OPERATING LIMITATIONS AND INFORMATION

GENERAL

§ 6.700 *Scope.* (a) The operating limitations in §§ 6.710 through 6.718 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 (§ 6.740), shall be expressed as markings and placards (§ 6.730), and shall be made available by such other means as will convey the information to the crew members.

OPERATING LIMITATIONS

§ 6.710 *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.

§ 6.711 *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 at maximum continuous power, nor greater than either of the following:

(1) 0.9V established in accordance with § 6.204, or

(2) 0.9 times the maximum speed demonstrated in accordance with § 6.140.

(b) It shall be permissible to vary the never-exceed speed with altitude and rotor rpm, provided that the ranges of these variables are sufficiently large to allow an operationally practical and safe variation of the never-exceed speeds.

§ 6.712 *Operating speed range.* An operating speed range shall be established for each rotorcraft.

§ 6.713 *Rotor speed.* Rotor rpm limitations shall be established as set forth in paragraphs (a) and (b) of this section. (See also § 6.710.)

(a) *Maximum power off (autorotation).* Not to exceed 95 percent of the maximum design rpm determined under § 6.204 (b) or 95 percent of the maximum rpm demonstrated during the type tests (see § 6.103 (b)), whichever is less.

(b) *Minimum.*—(1) *Power off.* Not less than 105 percent of the higher of the following:

(i) The minimum demonstrated during the type test (see § 6.103 (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 (see § 6.103 (a)), or

(ii) The minimum determined by design substantiation and not higher than a value determined in compliance with § 6.103 (a).

§ 6.714 *Powerplant limitations.* The powerplant limitations set forth in paragraphs (a) through (c) of this section shall be established for the rotorcraft. They shall not exceed the corresponding limits established as a part of the type certification of the engine 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 greater than the maximum value determined by the rotor design, nor greater than the maximum value demonstrated during type tests.

(2) The maximum permissible manifold pressure.

(3) The time limit upon the use of the corresponding power.

(4) The maximum allowable cylinder head, coolant outlet, or oil temperatures, if applicable when the time limit of subparagraph (3) of this paragraph exceeds two minutes.

(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 than the maximum value demonstrated during type tests.

(2) The minimum rotational speed demonstrated in compliance with the rotor speed requirements as prescribed in § 6.713 (b) (2). (See §§ 6.103, 6.710, and 6.711.)

(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.

§ 6.715 *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. Such an envelope shall be established in full autorotation for single-engine helicopters and with one engine inoperative for multi-engine helicopters provided that engine isolation design features are incorporated to assure continued operation of the remaining engines. (See § 6.741 (f).)

§ 6.716 *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 §§ 6.101 and 6.102.

§ 6.717 *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 § 6.718. 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.

§ 6.718 *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.)

§ 6.719 *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 number or by other equivalent means.

MARKINGS AND PLACARDS

§ 6.730 *General.* (a) The markings and placards specified in §§ 6.731 through 6.738 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.

§ 6.731 *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.

§ 6.732 *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 §§ 6.612 (a), 6.710, 6.711, 6.712, 6.713, and 6.715.)

(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.

§ 6.733 *Magnetic direction indicator.* A placard shall be installed on or in close proximity to the magnetic direction indicator which shall comply with the requirements of paragraphs (a) through (c) of this section. (See § 6.612 (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.

§ 6.734 *Powerplant instruments; general.* All required powerplant instruments shall be marked in accordance with paragraphs (a) through (c) of this section. (See § 6.613.)

(a) The maximum and the minimum (if applicable) safe operation 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.

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§ 6.735 *Oil quantity indicator.* Oil quantity indicators shall be marked in sufficient increments to indicate readily and accurately the quantity of oil. (See § 6.613 (d).)

§ 6.736 *Fuel quantity indicator.* 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 §§ 6.421 and 6.613 (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 § 6.741 (g).)

§ 6.737 *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 § 6.353.)

(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 operation of the rotorcraft (such as a rotor pitch or retractable landing gear indicator), they shall be marked in such a manner that the crew members at all times can determine the position of the unit.

(2) Emergency controls shall be colored red and shall be marked to indicate their method of operation.

§ 6.738 *Miscellaneous markings and placards*—(a) *Baggage compartments and ballast location.* Each baggage and cargo compartment as well as the ballast location shall bear a placard stating the maximum allowable weight of contents and, if applicable, any other limitation on contents found necessary due to loading requirements. When the maximum permissible weight to be carried in a seat is less than 170 pounds (see § 6.101 (b) (4)), a placard shall be permanently attached to the seat structure stating the 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 be marked on or adjacent to the appropriate filler cover.

(1) The word "fuel", the minimum permissible fuel octane number for the engines installed, and the usable fuel tank capacity. (See § 6.423 (c).)

(2) The word "oil" and the oil tank capacity. (See § 6.441 (e).)

(c) *Emergency exit placards.* Emergency exit placards and operating controls shall be colored red. A placard shall be located adjacent to the controls which clearly indicates the location of the exit and the method of operation. (See § 6.357.)

(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 operating 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

§ 6.740 *General.* (a) A Rotorcraft Flight Manual shall be furnished with each rotorcraft, except that a Rotorcraft Flight Manual is not required for helicopters certificated under this part; instead, the information prescribed in this part for inclusion in the Rotorcraft Flight Manual shall be made available to the operator by the manufacturer in the form of clearly stated placards, markings, or manuals. If all of the operating limitations are not included in the form of placards and markings on the helicopter then the portion of the manual supplied by the manufacturer containing the operating limitations prescribed in § 6.741 shall be approved and furnished with each helicopter.

(b) The portions of the manual listed in §§ 6.741 through 6.744 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.

§ 6.741 *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 shall include the information necessary for the marking of the limitations on or adjacent to the indicators as required. (See § 6.732.) 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 § 6.714) and to permit marking the instruments as required by 6.736.

(c) *Weight and load.* The rotorcraft weights gravity limits required 6.102 shall be included, the items of equipment empty weight is based. W ety of possible loading cc rants, instructions shall l facilitate observance of th

(d) *Flight crew.* When of more than one is require and functions of the min crew determined in acco § 6.717 shall be described.

(e) *Type of operation.* of operation(s) shall be liste the rotorcraft and its equipme tions have been approved. (S

(f) *Limiting heights.* Suffic mation shall be included to o limiting heights and corr speeds for safe landing after p ure. (See § 6.715.)

(g) *Unusable fuel.* If the fuel supply in any tank exceeds lon or 5 percent of the tank c whichever is the greater, warni be provided to indicate to the flig sonnel that the fuel remaining tank when the quantity indicato zero cannot be used safely in (See § 6.421.)

§ 6.742 *Operating procedures.* section of the manual devoted to op ing procedures shall contain inform concerning normal and emergency cedures and other pertinent informa including take-off and landing pr dures and their appropriate air sp peculiar to the rotorcraft's opera characteristics which are necessary safe operation.

§ 6.743 *Performance informat* Information relative to the items of p formance set forth in paragraphs and (b) of this section shall be cluded.

(a) The steady rates of climb a hovering ceilings together with the c responding air speeds and other p tinent information, including the c culated effect of altitude and tempe ture. (See §§ 6.112 and 6.113.)

(b) Maximum wind allowable safe operation near the ground. (§ 6.121 (d).)

§ 6.744 *Marking and placard in mation.* (See § 6.730.)

ROTORCRAFT IDENTIFICATION DATA

§ 6.750 *Identification plate.* A proof identification plate shall be sec ly attached to the structure in ar cessible location where it will not be defaced during normal service. identification plate shall not be p in a location where it might be ex to be destroyed or lost in the event accident. The identification plat contain the identification data re by § 1.50 of this subchapter.

§ 6.751 *Identification marks.* T tionality and registration marks s permanently affixed in accordan § 1.100 of this subchapter.

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