

to those structures for which experience has shown this method to be reliable. In other cases, substantiating load tests must be made.

(b) Proof of compliance with the strength requirements of this subpart must include—

- (1) Dynamic and endurance tests of rotors, rotor drives, and rotor controls;
- (2) Limit load tests of the control system, including control surfaces;
- (3) Operation tests of the control system;
- (4) Flight stress measurement tests;
- (5) Landing gear drop tests; and
- (6) Any additional tests required for new or unusual design features.

(Secs. 604, 605, 72 Stat. 778, 49 U.S.C. 1424, 1425)

[Doc. No. 5084, 29 FR 16150, Dec. 3, 1964, as amended by Amdt. 29-4, 33 FR 14106, Sept. 18, 1968; Amdt. 27-26, 55 FR 8001, Mar. 6, 1990]

#### § 29.309 Design limitations.

The following values and limitations must be established to show compliance with the structural requirements of this subpart:

- (a) The design maximum and design minimum weights.
- (b) The main rotor r.p.m. ranges, power on and power off.
- (c) The maximum forward speeds for each main rotor r.p.m. within the ranges determined under paragraph (b) of this section.
- (d) The maximum rearward and side-ward flight speeds.
- (e) The center of gravity limits corresponding to the limitations determined under paragraphs (b), (c), and (d) of this section.
- (f) The rotational speed ratios between each powerplant and each connected rotating component.
- (g) The positive and negative limit maneuvering load factors.

#### FLIGHT LOADS

#### § 29.321 General.

(a) The flight load factor must be assumed to act normal to the longitudinal axis of the rotorcraft, and to be equal in magnitude and opposite in direction to the rotorcraft inertia load factor at the center of gravity.

(b) Compliance with the flight load requirements of this subpart must be shown—

- (1) At each weight from the design minimum weight to the design maximum weight; and
- (2) With any practical distribution of disposable load within the operating limitations in the Rotorcraft Flight Manual.

#### § 29.337 Limit maneuvering load factor.

The rotorcraft must be designed for—

- (a) A limit maneuvering load factor ranging from a positive limit of 3.5 to a negative limit of -1.0; or
- (b) Any positive limit maneuvering load factor not less than 2.0 and any negative limit maneuvering load factor of not less than -0.5 for which—

- (1) The probability of being exceeded is shown by analysis and flight tests to be extremely remote; and
- (2) The selected values are appropriate to each weight condition between the design maximum and design minimum weights.

[Doc. No. 5084, 29 FR 16150, Dec. 3, 1964, as amended by Amdt. 27-26, 55 FR 8002, Mar. 6, 1990]

#### § 29.339 Resultant limit maneuvering loads.

The loads resulting from the application of limit maneuvering load factors are assumed to act at the center of each rotor hub and at each auxiliary lifting surface, and to act in directions and with distributions of load among the rotors and auxiliary lifting surfaces, so as to represent each critical maneuvering condition, including power-on and power-off flight with the maximum design rotor tip speed ratio. The rotor tip speed ratio is the ratio of the rotorcraft flight velocity component in the plane of the rotor disc to the rotational tip speed of the rotor blades, and is expressed as follows:

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

where—

V=The airspeed along the flight path (f.p.s.);  
 $a$ =The angle between the projection, in the plane of symmetry, of the axis of no feathering and a line perpendicular to the flight

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path (radians, positive when axis is pointing aft);  
 $\Omega$ =The angular velocity of rotor (radians per second); and  
 $R$ =The rotor radius (ft.).

### § 29.341 Gust loads.

Each rotorcraft must be designed to withstand, at each critical airspeed including hovering, the loads resulting from vertical and horizontal gusts of 30 feet per second.

### § 29.351 Yawing conditions.

(a) Each rotorcraft must be designed for the loads resulting from the maneuvers specified in paragraphs (b) and (c) of this section, with—

(1) Unbalanced aerodynamic moments about the center of gravity which the aircraft reacts to in a rational or conservative manner considering the principal masses furnishing the reacting inertia forces; and

(2) Maximum main rotor speed.

(b) To produce the load required in paragraph (a) of this section, in unaccelerated flight with zero yaw, at forward speeds from zero up to  $0.6 V_{NE}$ —

(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stops or by the maximum pilot force specified in § 29.397(a);

(2) Attain a resulting sideslip angle or  $90^\circ$ , whichever is less; and

(3) Return the directional control suddenly to neutral.

(c) To produce the load required in paragraph (a) of the section, in unaccelerated flight with zero yaw, at forward speeds from  $0.6 V_{NE}$  up to  $V_{NE}$  or  $V_H$ , whichever is less—

(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stops or by the maximum pilot force specified in § 29.397(a);

(2) Attain a resulting sideslip angle or  $15^\circ$ , whichever is less, at the lesser speed of  $V_{NE}$  or  $V_H$ ;

(3) Vary the sideslip angles of paragraphs (b)(2) and (c)(2) of this section directly with speed; and

(4) Return the directional control suddenly to neutral.

[Amdt. 29-26, 55 FR 8002, Mar. 6, 1990, as amended by Amdt. 29-41, 62 FR 46173, Aug. 29, 1997]

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### § 29.361 Engine torque.

The limit engine torque may not be less than the following:

(a) For turbine engines, the highest of—

(1) The mean torque for maximum continuous power multiplied by 1.25;

(2) The torque required by § 29.923;

(3) The torque required by § 29.927; or

(4) The torque imposed by sudden engine stoppage due to malfunction or structural failure (such as compressor jamming).

(b) For reciprocating engines, the mean torque for maximum continuous power multiplied by—

(1) 1.33, for engines with five or more cylinders; and

(2) Two, three, and four, for engines with four, three, and two cylinders, respectively.

[Amdt. 29-26, 53 FR 34215, Sept. 2, 1988]

### CONTROL SURFACE AND SYSTEM LOADS

### § 29.391 General.

Each auxiliary rotor, each fixed or movable stabilizing or control surface, and each system operating any flight control must meet the requirements of §§ 29.395 through 29.399, 29.411, and 29.427.

[Amdt. 29-26, 55 FR 8002, Mar. 6, 1990, as amended by Amdt. 29-41, 62 FR 46173, Aug. 29, 1997]

### § 29.395 Control system.

(a) The reaction to the loads prescribed in § 29.397 must be provided by—

(1) The control stops only;

(2) The control locks only;

(3) The irreversible mechanism only (with the mechanism locked and with the control surface in the critical positions for the effective parts of the system within its limit of motion);

(4) The attachment of the control system to the rotor blade pitch control horn only (with the control in the critical positions for the affected parts of the system within the limits of its motion); and

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