

European Aviation Safety Agency

DECISION NO. 2003/17/RM

OF THE EXECUTIVE DIRECTOR OF THE AGENCY

of 14 November 2003

on certification specifications for very light rotorcraft (« CS-VLR »)

THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY,

Having regard to Regulation (EC) No 1592/2002 of the European Parliament and of the Council of 15 July 2002 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency¹ (hereinafter referred to as the “Basic Regulation”), and in particular Articles 13 and 14 thereof,

Having regard to the Commission Regulation (EC) No 1702/2003 of 24 September 2003² laying down implementing rules for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations, in particular 21A.16A of Part 21 thereof;

Whereas :

- (1) The Agency shall issue certification specifications, including airworthiness codes and acceptable means of compliance, as well as guidance material to be used in the certification process.
- (2) The Agency has, pursuant to Article 43 of the Basic Regulation, consulted widely interested parties on the matters which are subject to this Decision and following that consultation provided a written response to the comments received,

HAS DECIDED AS FOLLOWS:

¹ OJ L 240, 7.09.2002, p. 1.

² OJ L 243, 27.09.2003, p. 6.

Article 1

The certification specifications, including airworthiness codes and acceptable means of compliance, for very light rotorcraft and for engines to be installed thereon are those laid down in the Annex to this Decision.

Article 2

This Decision shall enter into force on 14 November 2003. It shall be published in the *Official Publication of the Agency*.

Done at Brussels, 14 November 2003.

For the European Aviation Safety Agency,

Patrick GOUDOU

Executive Director

**Certification Specifications
for
Very Light Rotorcraft**

CS-VLR

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CS-VLR

VERY LIGHT ROTORCRAFT

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EASA Certification Specifications
for
VERY LIGHT ROTORCRAFT

CS-VLR
Book 1

Airworthiness code

SUBPART A – GENERAL

CS VLR.1 Applicability
(See AMC VLR.1)

This airworthiness code is applicable to very light rotorcraft (helicopters) with maximum certified take-off weights not exceeding 600 kg which:

- (a) Are of a simple design.
- (b) Are designed to carry not more than two occupants.
- (c) Are not powered by turbine and/or rocket engines.
- (d) Are restricted to VFR day operations.

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SUBPART B – FLIGHT

GENERAL

CS VLR.21 Proof of compliance

Each requirement of this subpart must be met at each appropriate combination of weight and center of gravity within the range of loading conditions for which

(a) By tests upon a rotorcraft of the type for which certification is requested, or by calculations based on, and equal in accuracy to, the results of testing; and

(b) By systematic investigation of each required combination of weight and centre of gravity, if compliance cannot be reasonably inferred from combinations investigated.

CS VLR.25 Weight limits

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

(1) Not more than-

(i) The highest weight selected by the applicant;

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

(iii) The highest weight at which compliance with each applicable flight requirement of this CS-VLR is shown.

(2) Not less than the higher value resulting from the sum of:

(i) The empty weight determined under CS VLR.29, the weight of fuel for one hour of operation at rated maximum continuous power, the weight of full oil capacity, and for each seat, an occupant weight of 86 kg; or

(ii) The empty weight determined under CS VLR.29, the weight of the fuel corresponding to maximum fuel capacity, the weight of full oil capacity, one pilot weighing 86 kg and the weight of removable ballast.

(b) *Minimum weight.* The minimum weight (the lowest weight at which compliance with each applicable requirement of this CS-VLR is shown) must be established so that it is

(1) Not more than the sum of:

(i) The empty weight determined under CS VLR.29;

(ii) The weight of the pilot assumed as 77 kg or any other lower weight selected by the applicant;

(2) Not less than the design minimum weight at which compliance with each applicable structural loading condition and each applicable flight requirement of this CS-VLR is shown

CS VLR.27 Centre of gravity limits

The extreme forward and aft centres of gravity and, where critical, the extreme lateral centres of gravity must be established for each weight established in CS VLR.25. Such an extreme may not lie beyond-

(a) The extremes selected by the applicant;

(b) The extremes within which the structure is proven; or

(c) The extremes within which compliance with the applicable flight requirements is shown.

CS VLR.29 Empty weight and corresponding centre of gravity

(a) The empty weight and corresponding centre of gravity must be determined by weighing the rotorcraft without the crew and payload, but with-

(1) Fixed ballast;

(2) Unusable fuel determined under CS VLR.959; and

(3) Full operating fluids, including-

(i) Oil;

(ii) Other fluids required for normal operation of rotorcraft systems.

(b) The condition of the rotorcraft at the time of determining empty weight must be one that is well defined and can be easily repeated, particularly with respect to the weights of fuel, oil, coolant, and installed equipment.

CS VLR.31 Removable ballast

Removable ballast may be used in showing compliance with the flight requirements of this Subpart.

CS VLR.33 Main rotor speed and pitch limits

(a) *Main rotor speed limits.* A range of main rotor speeds must be established that-

(1) With power-on, provides adequate margin to accommodate the variations in rotor speed occurring in any appropriate maneuver, and is consistent with the kind of governor or synchronizer used; and

(2) With power-off, allows each appropriate autorotative maneuver to be performed throughout the ranges of airspeed and weight for which certification is requested.

(b) *Normal main rotor high pitch limits (power-on).* For rotorcraft, except helicopters required to have a main rotor low speed warning under sub-paragraph (e), it must be shown, with power-on and without exceeding approved engine maximum limitations, that main rotor speeds substantially less than the minimum approved main rotor speed will not occur under any sustained flight condition. This must be met by-

(1) Appropriate setting of the main rotor high pitch stop;

(2) Inherent rotorcraft characteristics that make unsafe low main rotor speeds unlikely; or

(3) Adequate means to warn the pilot of unsafe main rotor speeds.

(c) *Normal main rotor low pitch limits (power-off).* It must be shown, with power-off, that-

(1) The normal main rotor low pitch limit provides sufficient rotor speed, in any autorotative condition, under the most critical combinations of weight and airspeed; and

(2) It is possible to prevent overspeeding of the rotor without exceptional piloting skill.

(d) *Emergency high pitch.* If the main rotor high pitch stop is set to meet sub-paragraph (b)(1), and if that stop cannot be exceeded inadvertently, additional pitch may be made available for emergency use.

(e) *Main rotor low speed warning for helicopters.* There must be a main rotor low speed warning which meets the following requirements:

(1) The warning must be furnished to the pilot in all flight conditions, including power-on and power-off flights, when the speed of a main rotor approaches a value that can jeopardize safe flight.

(2) The warning may be furnished either through the inherent aerodynamic qualities of the helicopter or by a device.

(3) The warning must be clear and distinct under all conditions, and must be clearly distinguishable from other warnings. A visual device that requires the attention of the crew within the cockpit is not acceptable by itself.

(4) If a warning device is used, the device must automatically deactivate and reset when the low-speed condition is corrected. If the device has an audible warning, it must also be equipped with a means for the pilot to manually silence the audible warning before the low-speed condition is corrected.

PERFORMANCE

CS VLR.45 General

(a) Unless otherwise prescribed, the performance requirements of this Subpart must be met for still air and a standard atmosphere (at sea-level).

(b) The performance must correspond to the engine power available under the particular ambient atmospheric conditions, based on a relative humidity of 80% and considering the particular flight condition.

(c) The available power must correspond to engine power, not exceeding the approved power less installation losses on power absorbed by accessories.

CS VLR.51 Take-off

(a) The take-off, with take-off power and rpm, and with the extreme forward centre of gravity-

(1) May not require exceptional piloting skill or exceptionally favorable conditions; and

(2) Must be made in such a manner that a landing can be made safely at any point along the flight path if the engine fails.

(b) Sub-paragraph (a) must be met throughout the ranges of altitude and weight for which certification is requested.

CS VLR.65 Climb

The steady rate of climb must be determined at maximum continuous power:

(a) At a speed for which certification is requested;

(b) From sea level up to an altitude for which certification is requested;

(c) At weights and temperatures for which certification is requested.

CS VLR.71 Glide performance

The minimum rate of descent airspeed and the best angle-of-glide airspeed must be determined in autorotation at-

(a) Maximum weight; and

(b) Rotor speed(s) selected by the applicant.

CS VLR.73 Performance at minimum operating speed

(a) The hovering ceiling must be determined, over the ranges of weight, altitude and temperature for which certification is requested, with -

(1) Take-off power;

(2) The helicopter in ground effect at a height consistent with normal take-off procedures; and

(b) The hovering ceiling determined under sub-paragraph (a) must be at least 915m (3000 ft) at maximum weight with a standard atmosphere.

CS VLR.75 Landing

(a) The rotorcraft must be able to be landed with no excessive vertical acceleration, no tendency to bounce, nose over, ground loop, porpoise, or water loop, and without exceptional piloting skill or exceptionally favourable conditions, with-

(1) Approach or glide speeds appropriate to the type of rotorcraft and selected by the applicant;

(2) The approach and landing made with power-off;

(3) The approach and landing entered from steady autorotation.

CS VLR.79 Limiting height-speed envelope

(a) If there is any combination of height and forward speed (including hover) under which a safe landing cannot be made under applicable power failure condition in sub-paragraph (b), a limiting height-speed envelope must be established (including all pertinent information) for that condition, throughout the ranges of-

(1) Altitude, from standard sea level conditions to the maximum altitude capability of the rotorcraft, or 2134m (7000 ft), whichever is less; and

(2) Weight, from the maximum weight (at sea-level) to the lesser weight selected by the applicant for each altitude covered by sub-paragraph (a)(1). The weight at altitudes above sea-level may not be less than the maximum weight or the highest weight allowing hovering out of ground effect whichever is lower.

(b) The applicable power failure conditions are full auto-rotation.

FLIGHT CHARACTERISTICS

CS VLR.141 General

The rotorcraft must -

(a) Except as specifically required in the applicable paragraph, meet the flight characteristics requirements of this Subpart-

(1) At the altitudes and temperatures expected in operation;

(2) Under any critical loading condition within the range of weights and centres of gravity for which certification is requested;

(3) For power-on operations, under any condition of speed and rotor rpm for which certification is requested; and

(4) For power-off operations, under any condition of speed and rotor rpm for which certification is requested that is attainable with the controls rigged in accordance with the approved rigging instructions and tolerances.

(b) Be able to maintain any required flight condition and make a smooth transition from any flight condition to any other flight condition without exceptional piloting skill, alertness, or strength, and without danger of exceeding the limit load factor under any operating condition probable for the type, including sudden complete power failure.

CS VLR.143 Controllability and manoeuvrability

(a) The rotorcraft must be safely controllable and manoeuvrable-

- (1) During steady flight; and
- (2) During any manoeuvre appropriate to the type, including-
 - (i) Take-off;
 - (ii) Climb;
 - (iii) Level flight;
 - (iv) Turning flight;
 - (v) Glide;
 - (vi) Landing (power-on and power-off); and
 - (vii) Recovery to power-on flight from a bailed autorotative approach

(b) The margin of cyclic control must allow satisfactory roll and pitch control at V_{NE} with-

- (1) Critical weight;
- (2) Critical centre of gravity;
- (3) Critical rotor rpm; and
- (4) Power off and power-on.

(c) A wind velocity of not less than 31 km/h (17 kts) must be established in which the rotorcraft can be operated without loss of control on or near the ground in any maneuver appropriate to the type (such as crosswind take-offs, sideward flight, and rearward flight) with-

- (1) Critical weight;
- (2) Critical centre of gravity;
- (3) Critical rotor rpm

(4) Altitude from standard sea level conditions to the maximum altitude for which landing and take-off certification is sought.

(d) The rotorcraft, after complete engine failure, must be controllable over the range of speeds and altitudes for which certification is requested when such power failure occurs with maximum continuous power and critical weight. No corrective action time delay for any condition following power failure may be less than-

- (1) For the cruise condition, one second, or normal pilot reaction time (whichever is greater); and
- (2) For any other condition, normal pilot reaction time.

(See AMC VLR.143(d))

(e) For helicopters for which a V_{NE} (power off) is established in CS-VLR 1505(c), compliance must be demonstrated with the following requirements with critical weight, critical centre of gravity, and critical rotor rpm:

- (1) The helicopter must be safely slowed to V_{NE} (power-off), without exceptional pilot skill, after the engine is made inoperative at power-on V_{NE}
- (2) At a speed of 1.1 V_{NE} (power-off), the margin of cyclic control must allow satisfactory roll and pitch control with power off

CS VLR.151 Flight controls

(a) Longitudinal, lateral, directional, and collective controls may not exhibit excessive breakout force, friction, or preload.

(b) Control system forces and free play may not inhibit a smooth, direct rotorcraft response to control system input.

CS VLR.161 Trim control

The trim control-

(a) Must trim any steady longitudinal, lateral and collective control forces to zero in level flight at any appropriate speed; and

(b) May not introduce any undesirable discontinuities in control force gradients.

CS VLR.171 Stability: general

The rotorcraft must be able to be flown, without undue pilot fatigue or strain, in any normal manoeuvre for a period of time as long as that expected in normal operation. At least three landings and take-offs must be made during this demonstration.

CS VLR.173 Static longitudinal stability

(a) The longitudinal control must be designed so that a rearward movement of the control is necessary to obtain a speed less than the trim speed, and a forward movement of the control is necessary to obtain a speed more than the trim speed.

(b) With the throttle and collective pitch held constant during the manoeuvres specified in CS VLR.175(a) to (c), the slope of the control position versus speed curve must be positive throughout the full range of altitude for which certification is requested.

(c) During manoeuvre specified in CS VLR.175(d), the longitudinal control position versus speed curve may have a negative slope within the specified speed range if the negative motion is not greater than 10 % of the total control travel.

CS VLR.175 Demonstration of static longitudinal stability

(a) *Climb*. Static longitudinal stability must be shown in the climb condition at speeds from $0.85 V_Y$ to $1.2 V_Y$, with-

- (1) Critical weight;
- (2) Critical centre of gravity;
- (3) Maximum continuous power; and
- (4) The rotorcraft trimmed at V_Y .

(b) *Cruise*. Static longitudinal stability must be shown in the cruise condition at speeds 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-

- (1) Critical weight;
- (2) Critical centre of gravity;

(3) Power for level flight at $0.9 V_H$ or $0.9 V_{NE}$, whichever is less; and

(4) The rotorcraft trimmed at $0.9 V_H$ or $0.9 V_{NE}$ whichever is less.

(c) *Autorotation*. Static longitudinal stability must be shown in autorotation at airspeeds from 0.5 times the speed for minimum rate of descent to V_{NE} or to $1.1 V_{NE}$ (power-off) if V_{NE} (power-off) is established under CS VLR 1505 (c), and with -

- (1) Critical weight;
- (2) Critical centre of gravity;
- (3) Power-off;
- (4) The rotorcraft trimmed at appropriate speeds found necessary by the Agency to demonstrate stability throughout the prescribed speed range.

(d) *Hovering*. For helicopters, the longitudinal cyclic control must operate with the sense and direction of motion prescribed in CS VLR.173 between the maximum approved rearward speed and a forward speed of 31 km/h (17 kts) with-

- (1) Critical weight;
- (2) Critical centre of gravity;
- (3) Power required to maintain an approximate constant height in ground effect; and
- (4) The helicopter trimmed for hovering.

CS VLR.177 Static directional stability

Static directional stability must be positive with throttle and collective controls held constant at the trim conditions specified in CS VLR.175(a) and (b). This must be shown by steadily increasing directional control deflection for sideslip angles up to ± 10 degrees from trim. Sufficient cues must accompany sideslip to alert the pilot when approaching sideslip limits.

GROUND AND WATER HANDLING CHARACTERISTICS

CS VLR.231 General

The rotorcraft must have satisfactory ground and water handling characteristics, including freedom from uncontrollable tendencies in any condition expected in operation.

CS VLR.239 Spray characteristics

If certification for water operation is requested, no spray characteristics during taxiing, take-off, or landing may obscure the vision of the pilot or damage the rotors, propellers, or other parts of the rotorcraft.

CS VLR.241 Ground resonance

The rotorcraft may have no dangerous tendency to oscillate on the ground with the rotor turning.

MISCELLANEOUS FLIGHT REQUIREMENTS**CS VLR.251 Vibration**

Each part of the rotorcraft must be free from excessive vibration under each appropriate speed and power condition.

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SUBPART C - STRENGTH REQUIREMENTS

GENERAL

CS VLR.301 Loads

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

(b) Unless otherwise provided, the specified air, ground, and water loads must be placed in equilibrium with inertia forces, considering each item of mass in the rotorcraft. These loads must be distributed to closely approximate or conservatively represent actual conditions.

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

CS VLR.303 Factor of safety

Unless otherwise provided, a factor of safety of 1.5 must be used. This factor applies to external and inertia loads unless its application to the resulting internal stresses is more conservative.

CS VLR.305 Strength and deformation

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

(b) The structure must be able to support ultimate loads without failure. This must be shown by-

- (1) Applying ultimate loads to the structure in a static test for at least 3 seconds; or
- (2) Dynamic tests simulating actual load application.

CS VLR.307 Proof of structure

(a) Compliance with the strength and deformation requirements of this Subpart must be shown for each critical loading condition accounting for the environment to which the structure will be exposed in operation. Structural analysis (static or fatigue) may be used only if the structure conforms to those structures for which experience has shown this method to be reliable. In

other cases, substantiating load tests must be made. (See AMC VLR 307(a))

(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 control system;
- (4) Flight stress measurement tests;
- (5) Landing gear drop tests; and
- (6) Any additional tests required for new or unusual design features.

CS VLR.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 weight.
- (b) The main rotor rpm ranges power-on and power-off.
- (c) The maximum forward speeds for each main rotor rpm within the ranges determined in sub-paragraph (b).
- (d) The maximum rearward and sideward flight speeds.
- (e) The centre of gravity limits corresponding to the limitations determined in sub-paragraphs (b), (c), and (d).
- (f) The rotational speed ratios between powerplant and each connected rotating component.
- (g) The positive and negative limit manoeuvring load factors.

FLIGHT LOADS

CS VLR.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 centre 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.

CS VLR.337 Limit manoeuvring load factor

The rotorcraft must be designed for-

(a) A limit manoeuvring load factor ranging from a positive limit of 3.5 to a negative limit of -1.0; or

(b) Any positive limit manoeuvring load factor not less than 2.0 and any negative limit manoeuvring 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.

CS VLR.339 Resultant limit manoeuvring loads

The loads resulting from the application of limit manoeuvring load factors are assumed to act at the centre of each rotor hub and 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 manoeuvring 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 (m/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 path (radians, positive when the axis is pointing aft);

Ω = The angular velocity of the rotor (radians per second); and

R = The rotor radius (m).

CS VLR.341 Gust loads

The rotorcraft must be designed to withstand, at each critical airspeed including hovering, the loads resulting from a vertical gust of 9.1 m/s (30 ft/s).

CS VLR.351 Yawing conditions

(a) Each rotorcraft must be designed for the loads resulting from the manoeuvres specified in subparagraphs (b) and (c) with-

(1) Unbalanced aerodynamic moments about the centre 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 sub-paragraph (a), in unaccelerated flight with zero yaw, at forward speed from zero up to $0.6 V_{NE}$ -

(1) Displace the cockpit directional control suddenly to the maximum deflection limited by the control stop or by the pilot force specified in CS VLR.395(a);

(2) Attain a resulting sideslip angle or 90° , whichever is less; and

(3) Return the directional control suddenly to neutral.

(c) To produce the load required in sub-paragraph (a), 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 pilot force specified in CS VLR.395 (a);

- (2) Attain a resulting sideslip angle or 15°, whichever is less, at the lesser speed of V_{NE} or V_H.
- (3) Vary the sideslip angles of sub-paragraphs (b)(2) and (c)(2) directly with speed; and
- (4) Return the directional control suddenly to neutral.

CS VLR.361 Engine torque

The limit torque may not be less than the mean torque for maximum continuous power multiplied by-

- (1) For four- stroke engines-
 - (i) 1.33, for engines with five or more cylinders; and
 - (ii) 2, 3, 4 or 8, for engines with four, three, two or one cylinder, respectively.
- (2) For two- stroke engines-
 - (i) 2 for engines with three or more cylinders,
 - (ii) 3, or 6, for engines with two or one cylinder, respectively.

CONTROL SURFACE AND SYSTEM LOADS

CS VLR.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 CS VLR.395, -397, -399, -411, and -427.

CS VLR.395 Control system

(a) The part of each control system from the pilot's controls to the control stops must be designed to withstand pilot forces of not less than-

- (1) The forces specified in CS VLR.397; or
- (2) If the system prevents the pilot from applying the limit pilot forces to the system, the maximum forces that the system allows the pilot to apply, but not less than 0.60 times the forces specified in CS VLR.397.

(b) Each primary control system, including its supporting structure, must be designed as follows:

(1) The system must withstand loads resulting from the limit pilot forces prescribed in CS VLR.397.

(2) (Reserved)

(3) If the system design or the normal operating loads are such that a part of the system cannot react to the limit forces prescribed in CS VLR.397, that part of the system must be designed to withstand the maximum loads that can be obtained in normal operation. The minimum design loads must, in any case, provide a rugged system for service use, including consideration of fatigue, jamming, ground gusts, control inertia and friction loads. In the absence of rational analysis, the design loads resulting from 0.60 of the specified limit pilot forces are acceptable minimum design loads.

(4) If operational loads may be exceeded through jamming, ground gusts, control inertia, or friction, the system must withstand the limit pilot forces specified CS VLR.397, without yielding.

CS VLR.397 Limit pilot forces and torques

(a) Except as provided in sub-paragraph (b), the limit pilot forces are as follows:

- (1) For foot controls, 578 N (130 pounds).
- (2) For stick controls, 445 N (100 pounds) fore and aft, and 298 N (67 pounds) laterally.

(b) For flap, tab, stabilizer and rotor brake, the following apply;).

- (1) Crank, wheel, and lever controls
(25.4+R)x2.919 N where R= radius in mm

$$\frac{[(1+R)] \times 50 \text{ pounds}}{3}$$

where R=radius in inches

but not less than 222 N (50 pounds) nor more than 445 N (100 pounds) for hand operated controls or 578 N (130 pounds) for foot operated controls, applied at any angle within 20° of the plane of motion of the control.

- (2) Twist controls, 356 x R Nmm, where R = radius in mm. (80 x R inch-pounds, where R = radius in inches).

CS VLR.399 Dual control system

Each dual primary flight control system must be designed to withstand the loads that result when pilot

forces of 0.75 times those obtained under CS VLR.395 are applied-

- (a) In opposition; and
- (b) In the same direction.

CS VLR.411 Ground clearance: anti- torque device guard

(a) It must be impossible for the anti-torque device to contact the landing surface during a normal landing.

(b) If a guard is required to show compliance with sub-paragraph (a) -

- (1) Suitable design loads must be established for the guard; and
- (2) The guard and its supporting structure must be designed to withstand those loads.

CS VLR.427 Unsymmetrical loads

(a) Horizontal tail surfaces and their supporting structure must be designed for unsymmetrical loads arising from yawing and rotor wake effects in combination with the prescribed flight conditions.

(b) To meet the design criteria of sub-paragraph (a), in the absence of more rational data, both of the following must be met:

- (1) 100 % of the maximum loading from the symmetrical flight conditions acts on the surface on one side of the plane of symmetry and no loading acts on the other side.
- (2) 50 % of the maximum loading from the symmetrical flight conditions acts on the surface on each side of the plane of symmetry but in opposite directions.

(c) For empennage arrangements where the horizontal tail surfaces are supported by the vertical tail surfaces, the vertical tail surfaces and supporting structure must be designed for the combined vertical horizontal surface loads resulting from each prescribed flight condition, considered separately. The flight conditions must be selected so the maximum design loads are obtained on each surface. In the absence of more rational data, the unsymmetrical horizontal tail surface loading distributions described in this paragraph must be assumed.

GROUND LOADS

CS VLR.471 General

(a) *Loads and equilibrium.* For limits ground loads-

(1) The limit ground loads obtained in the landing conditions in this Subpart must be considered to be external loads that would occur in the rotorcraft structure if it were acting as a rigid body; and

(2) In each specified landing condition, the external loads must be placed in equilibrium with linear and angular inertia loads in a rational or conservative manner.

(b) *Critical centres of gravity.* The critical centres of gravity within the range for which certification is requested must be selected so that the maximum design loads are obtained in each landing gear element.

CS VLR.473 Ground loading conditions and assumptions

(a) For specified landing conditions, a design maximum weight must be used that is not less than the maximum weight. Rotor lift may be assumed to act through the centre of gravity throughout the landing impact. This lift may not exceed two-thirds of the design maximum weight.

(b) Unless otherwise prescribed, for each specified landing condition, the rotorcraft must be designed for a limit load factor of not less than the limit inertia load factor substantiated under CS VLR.725.

CS VLR.475 Shock absorbers

Unless otherwise prescribed, for each specified landing condition, the shock absorbers must be assumed to be in their most critical position.

CS VLR.501 Ground loading conditions: landing gear with skids

(a) *General.* Rotorcraft with landing gear with skids must be designed for the loading conditions specified in this paragraph. In showing compliance with this paragraph, the following apply:

- (1) The design maximum weight, centre of gravity, and load factor must be determined in CS VLR.471 to -475.

(2) Structural yielding of elastic spring members under limit loads is acceptable.

(3) Design ultimate loads for elastic spring members need not exceed those obtained in a drop test of the gear with-

(i) A drop height of 1.5 times that specified in CS VLR.725; and

(ii) An assumed rotor lift of not more than 1.5 times that used in the limit drop tests prescribed in CS VLR.725.

(4) Compliance with sub-paragraphs (b) to (e) must be shown with-

(i) The gear in its most critically deflected position for the landing condition being considered; and

(ii) The ground reactions rationally distributed along the bottom of the skid tube.

(b) *Vertical reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the vertical reactions must be applied as prescribed in sub-paragraph (a).

(c) *Drag reactions in the level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical reactions must be combined with horizontal drag reactions of 50 % of the vertical reaction applied at the ground

(2) The resultant ground loads must equal the vertical load specified in sub-paragraph (b).

(d) *Sideloads in level landing attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of both skids, the following apply:

(1) The vertical ground reaction must be-

(i) Equal to the vertical loads obtained in the condition specified in sub-paragraph (b); and

(ii) Divided equally among the skids.

(2) The vertical ground reactions must be combined with a horizontal sideload of 25 % of their value.

(3) The total sideload must be applied equally between the skids and along the length of the skids.

(4) The unbalanced moments are assumed to be resisted by angular inertia.

(5) The skid gear must be investigated for-

(i) Inward acting side-loads; and

(ii) Outward acting side-loads.

(e) *One-skid landing loads in the level attitude.* In the level attitude, and with the rotorcraft contacting the ground along the bottom of one skid only, the following apply:

(1) The vertical load on the ground contact side must be the same as that obtained on that side in the condition specified in sub-paragraph (b).

(2) The unbalanced moments are assumed to be resisted by angular inertia.

(f) *Special conditions.* In addition to the conditions specified in sub-paragraphs (b) and (c), the rotorcraft must be designed for the following ground reactions:

(1) A ground reaction load acting up and aft at an angle of 45° to the longitudinal axis of the rotorcraft. This load must be-

(i) Equal to 1.33 times the maximum weight;

(ii) Distributed symmetrically among the skids;

(iii) Concentrated at the forward end of the straight part of the skid tube; and

(iv) Applied only to the forward end of the skid tube and its attachment to the rotorcraft.

(2) With the rotorcraft in the level landing attitude, a vertical ground reaction load equal to one-half of the vertical load determined in sub-paragraph (b). This load must be-

(i) Applied only to the skid tube and its attachment to rotorcraft; and

(ii) Distributed equally over 33.3 % of the length between the skid tube attachments and centrally located midway between the skid tube attachments.

CS VLR.505 Ski landing conditions

If certification for ski operation is requested, the rotorcraft, with skis, must be designed to withstand the following loading conditions (where P , is the maximum static load in N on each ski with the rotorcraft at design maximum weight, and n , is the limit load factor determined under CS VLR.473 (b)).

(a) Up-load conditions in which-

(1) A vertical load of Pn , and a horizontal load of $Pn/4$ are simultaneously applied at the pedestal bearings; and

(2) A vertical load of $1.33 P$ is applied at the pedestal bearings.

(b) A side-load condition in which a side load of $0.35 Pn$ is applied at the pedestal bearings in a horizontal plane perpendicular to the centerline of the rotorcraft.

(c) A torque-load condition in which a torque load of $1.33 P$ in Nm is applied to the ski about the vertical axis through the centerline of the pedestal bearings.

WATER LOADS**CS VLR.521 Float landing conditions**

If certification for float operation is requested, the rotorcraft, with floats, must be designed to withstand the following loading conditions (where the limit load factor is determined under CS VLR.473(b)):

(a) Up-load conditions in which-

(1) A load is applied so that, with the rotorcraft in the static level attitude, the resultant water reaction passes vertically through the centre of gravity; and

(2) The vertical load prescribed in sub-paragraph (a)(1) is applied simultaneously with an aft component of 0.25 times the vertical component.

(b) A side-load condition in which-

(1) A vertical load of 0.75 times the total vertical load specified in sub-paragraph (a)(1) is divided equally among the floats; and

(2) For each float, the load share determined in sub-paragraph (b)(1), combined with a total side load of 0.25 times the total vertical load specified in sub-paragraph (b)(1), is applied to the float only.

MAIN COMPONENT REQUIREMENTS**CS VLR.547 Main rotor structure**

(a) Each main rotor assembly (including rotor hubs and blades) must be designed as prescribed in this paragraph. (See AMC VLR.547(a)

(b) (Reserved)

(c) The main rotor structure must be designed to withstand the following loads prescribed in CS VLR.337 to -341:

(1) Critical flight loads.

(2) Limit loads occurring under normal conditions of autorotation. For this condition, the rotor rpm must be selected to include the effects of altitude.

(d) The main rotor structure must be designed to withstand loads simulating-

(1) For the rotor blades, hubs, and flapping hinges, the impact force of each blade against its stop during ground operation; and

(2) Any other critical condition expected in normal operation.

(e) The main rotor structure must be designed to withstand the limit torque at any rotational speed including zero. In addition-

(1) The limit torque need not be greater than the torque defined by a torque limiting device (where provided), and may not be less than the greater of-

(i) The maximum torque likely to be transmitted to the rotor structure in either direction; and

(ii) The limit engine torque specified in CS VLR.361.

(2) The limit torque must be distributed to the rotor blades in a rational manner.

CS VLR.549 Fuselage, landing gear, rotor pylon and engine structures

(a) Each fuselage, landing gear, rotor pylon and engine structure must be designed as prescribed in this paragraph. Resultant rotor forces may be represented as a single force applied at the rotor hub attachment point.

(b) Each structure must be designed to withstand-

(1) The critical loads prescribed in CS VLR.337 to -341; (see AMC VLR 549(b)(1))

(2) The applicable ground loads prescribed in CS VLR.471, -473, -501, -505, and -521; and

(3) The loads prescribed in CS VLR.547(d)(2) and (e).

(c) Auxiliary rotor thrust, and the balancing air and inertia loads occurring under accelerated flight conditions, must be considered.

(d) The engine mount and adjacent fuselage structure must be designed to withstand the loads occurring under accelerated flight and landing conditions, including engine torque.

EMERGENCY LANDING CONDITIONS

CS VLR.561 General

(a) The rotorcraft, although it may be damaged in emergency landing conditions on land or water, must be designed as prescribed in this paragraph to protect the occupants under those conditions.

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

(1) Proper use is made of seats, belts and other safety design provisions;

(2) [Reserved]

(3) Each occupant and each item of mass inside the cabin that could injure an occupant is restrained when subjected to the following ultimate inertial load factors relative to the surrounding structure:

(i) Upward, 4g;

(ii) Forward, 16g;

(iii) Sideward, 8g;

(iv) Downward, 20g;

(v) Rearward, 1.5g.

(c) The supporting structure must be designed to restrain, under any ultimate inertial load up to those specified in this paragraph, any item of mass above and/or behind the crew and passenger compartment that could injure an occupant if it came loose in an emergency landing. Items of mass to be considered include, but are not limited to, rotors, transmissions and

engines. The items of mass must be restrained for the following ultimate inertial load factors:

(1) Upward, 1.5g;

(2) Forward, 12g;

(3) Sideward, 6g

(4) Downward, 12g

(5) Rearward, 1.5g.

(d) Any fuselage structure in the area of internal fuel tanks below the passenger floor level must be designed to resist the following ultimate inertial factors and loads and to protect the fuel tanks from rupture when those loads are applied to that area:

(1) Upward, 1.5g;

(2) Forward, 4.0g;

(3) Sideward, 2.0g;

(4) Downward, 4.0g.

CS VLR.563 Emergency landing condition on water.

General The requirements of this paragraph are applicable to those rotorcraft for which take-off and landing on water is approved.

(a) The rotorcraft must initially contact the most critical wave for reasonably probable water conditions at forward velocities from zero up to 56 km/h (30 kts) in likely pitch, roll and yaw attitudes. The rotorcraft limit vertical descent velocity may not be less than 1.52 m/s relative to the mean water surface. Rotor lift may be used to act through the centre of gravity throughout the landing impact. This lift may not exceed two-thirds of the maximum design weight. A maximum forward velocity of less than 56km/h (30 kts) may be used in design if it can be demonstrated that the forward velocity selected would not be exceeded in a normal engine-out touchdown.

(b) In addition to the landing loads in subparagraph (a), each auxiliary float or its support and attaching structure in the airframe or fuselage, must be designed for the load developed by fully immersed float unless it can be shown that full immersion is unlikely. If full immersion is unlikely, the highest likely float buoyancy load must include consideration of a partially immersed float creating restoring moments to compensate the upsetting moments caused by sidewind, unsymmetrical helicopter loading, water wave action, helicopter inertia and probable structural damage and leakage associated to an emergency landing on water.

(c) Each practicable design measure, compatible with the general characteristics of the rotorcraft, must be taken to minimise the probability that in an emergency landing on water, the behaviour of the rotorcraft would cause immediate injury to the occupants or would make it impossible for them to escape.

(d) The probable behaviour of the rotorcraft in a water landing must be investigated.

(e) Unless the effects of the collapse of external doors and windows are accounted for in the investigation of the probable behaviour of the rotorcraft in a water landing, the external doors and windows must be designed to withstand the probable maximum local pressures.

that the probability of catastrophic fatigue failure is extremely remote without establishing replacement times, inspection intervals or other procedures in paragraph A.VLR.4 of Appendix A.

(c) *Replacement time evaluation.* It must be shown that the probability of catastrophic fatigue failure is extremely remote within a replacement time furnished in paragraph A.VLR.4 of Appendix A.

FATIGUE EVALUATION

CS VLR.571 Fatigue evaluation of flight structure

(a) *General.* Each portion of the flight structure (the flight structure includes rotors, rotor drive systems between the engines and the rotor hubs, controls, fuselage, landing gear and their related primary attachments) the failure of which could be catastrophic, must be identified and must be evaluated in sub-paragraph (b), (c). The following apply to each fatigue evaluation:

(1) The procedure for the evaluation must be approved.

(2) The locations of probable failure must be determined.

(3) Inflight measurement must be included in determining the following:

(i) Loads or stresses in all critical conditions throughout the range of limitations in CS-VLR.309, except that manoeuvring load factors need not exceed the maximum values expected in operation.

(ii) The effect of altitude upon these loads or stresses.

(4) The loading spectra must be as severe as those expected in operation including ground-air-ground cycles. The loading spectra must be based on loads or stresses determined in sub-paragraph (a)(3).

(b) *Fatigue tolerance evaluation.* It must be shown that the fatigue tolerance of the structure ensures

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SUBPART D - DESIGN AND CONSTRUCTION**GENERAL****CS VLR.601 Design**

(a) The rotorcraft may have no design features or details that experience has shown to be hazardous or unreliable.

(b) The suitability of each questionable design detail and part must be established by tests.

CS VLR.602 Critical parts

(a) A critical part is a part, the failure of which could have a catastrophic effect upon the rotorcraft, and for which critical characteristics have been identified which must be controlled to ensure the required level of integrity.

(b) If the type design includes critical parts, a critical parts list shall be established. Procedures shall be established to define the critical design characteristics, identify processes that affect those characteristics, and identify the design change and process change controls necessary for showing compliance with the quality assurance requirements of Part-21. (See AMC VLR.602)

CS VLR.603 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must-

(a) Be established on the basis of experience or tests;

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

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

CS VLR.605 Fabrication methods

(a) The methods of fabrication used must produce consistently sound structures. If a fabrication process, such as gluing, spot welding, or heat-treating, requires close control to reach this objective, the process must be performed according to an approved process specification.

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

CS VLR.607 Fasteners

(a) Each removable bolt, screw, nut, pin, or other fastener whose loss could jeopardize the safe operation of the rotorcraft must incorporate two separate locking devices. The fastener and its locking devices may not be adversely affected by the environmental conditions associated with the particular installation.

(b) No self-locking nut may be used on any bolt subject to rotation in operation unless a nonfriction locking device is used in addition to the self-locking device.

CS VLR.609 Protection of structure

Each part of the structure must-

(a) Be suitably protected against deterioration or loss of strength in service due to any cause, including-

- (1) Weathering;
- (2) Corrosion; and
- (3) Abrasion; and

(b) Have provisions for ventilation and drainage where necessary to prevent the accumulation of corrosive, flammable, or noxious fluids.

CS VLR.611 Inspection provisions

There must be means to allow the close examination of each part that requires-

- (a) Recurring inspection;
- (b) Adjustment for proper alignment and functioning; or
- (c) Lubrication.
- (d) Rigging and de-rigging.

CS VLR.613 Material strength properties and design values

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

(b) The design values must be chosen so that the probability of any structure being under-strength because of material variations is extremely remote. (See AMC VLR 613(b).)

(c) Where the temperature attained in an essential component or structure in normal operating conditions has a significant effect on strength, that effect must be taken into account. (See AMC VLR 613(c).)

CS VLR.615 Design properties

(a) Design properties may be used subject to the following conditions:

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

(2) Redundant structures, in which the failure of the individual elements would result in applied loads being safely distributed to other load carrying members, may be designed on the basis of the 90 % probability ("B" values).

(3) "A" and "B" values are defined as follows:

(i) An "A" value is a value above which at least 99 % of the population of values is expected to fall with a confidence of 95 %.

(ii) A "B" value is a value above which at least 90 % of the population of values is expected to fall with a confidence of 95 %.

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

(c) Material correction factors for structural items such as sheets, sheet-stringer combinations, and riveted joints, may be omitted if sufficient test data are obtained to allow a probability analysis showing that 90 % or more of the elements will equal or exceed allowable selected design values. (See AMC VLR 615.)

CS VLR.619 Special factors

The factor of safety prescribed in CS VLR.303 must be multiplied by the highest pertinent special factors prescribed in CS VLR.621 to 625 for each part of the structure whose strength is -

(a) Uncertain;

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

(c) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods. For composite structures, a special test factor which takes into account material variability and the effects of temperature and absorption of moisture shall be used.

CS VLR.621 Casting factors

For castings, the strength of which is substantiated by at least one static test and which are inspected by visual methods, a casting factor of 2.0 must be applied. This factor may be reduced to 1.25 providing the reduction is substantiated by tests on not less than three sample castings and all production castings are subjected to an approved visual and radiographic inspection or an approved equivalent nondestructive inspection methods.

CS VLR.623 Bearing factors

(a) Except as provided in sub-paragraph (b), each part that has clearance (free fit), and that is subject to pounding or vibration, must have a bearing factor large enough to provide for the effects of normal relative motion.

(b) No bearing factor need be used on a part for which any larger special factor is prescribed.

CS VLR.625 Fitting factors

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

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

(1) The fitting;

(2) The means of attachment; and

(3) The bearing on the joined members.

(b) No fitting factor need be used for joint designs based on comprehensive test data (such as continuous joints in metal plating, welded joints, and scarf joints in wood).

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

(d) For each seat, and safety belt with harness, its attachment to the structure must be shown by analysis, tests, or both, to be able to withstand the inertia forces prescribed in CS VLR.561 multiplied by a fitting factor of 1.33.

CS-VLR.629 Flutter

Each aerodynamic surface of the rotorcraft must be free from flutter under each appropriate speed and power condition.

ROTORS

CS VLR.653 Pressure venting and drainage of rotor blades

(a) For each rotor blade-

(1) There must be means for venting the internal pressure of the blade;

(2) Drainage holes must be provided for the blade; and

(3) The blade must be designed to prevent water from becoming trapped in it.

(b) Sub-paragraphs (a)(1) and (2) do not apply to sealed rotor blades capable of withstanding the maximum pressure differentials expected in service.

CS VLR.659 Mass balance

(a) The rotors and blades must be mass balanced as necessary to-

(1) Prevent excessive vibration; and

(2) Prevent flutter at any speed up to the maximum forward speed.

(b) The structural integrity of the mass balance installation must be substantiated.

CS VLR.661 Rotor blade clearance

There must be enough clearance between the rotor blades and other parts of the structure to prevent the blades from striking any part of the structure during any operating condition.

CS VLR.663 Ground resonance prevention means

(a) The reliability of the means for preventing ground resonance must be shown either by analysis and tests, or reliable service experience, or by showing through analysis or tests that malfunction or failure of a single means will not cause ground resonance.

(b) The probable range of variations, during service, of the damping action of the ground resonance prevention means must be established and must be investigated during the test required by CS VLR.241.

CONTROL SYSTEMS

CS VLR.671 General

(a) Each control and control system must operate with the ease, smoothness, and positiveness appropriate to its function.

(b) Each element of each flight control system must be designed, or distinctively and permanently marked, to minimize the probability of any incorrect assembly that could result in the malfunction of the system.

CS VLR.673 Primary flight control

Primary flight controls are those used by the pilot for immediate control of pitch, roll, yaw, and vertical motion of the rotorcraft.

CS VLR.674 Interconnected controls

Each primary flight control system must provide for safe flight and landing and operate independently after a malfunction, failure, or jam of any auxiliary interconnected control.

CS VLR.675 Stops

(a) Each control system must have stops that positively limit the range of motion of the pilot's controls.

(b) Each stop must be located in the system so that the range of travel of its control is not appreciably affected by-

- (1) Wear;
- (2) Slackness; or
- (3) Take-up adjustment.

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

(d) For each main rotor blade-

(1) Stops that are appropriate to the blade design must be provided to limit travel of the blade about its hinge points; and

(2) There must be means to keep the blade from hitting the droop stops during any operation other than starting and stopping the rotor.

CS VLR.679 Control system locks

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

- (a) Give unmistakable warning to the pilot when the lock is engaged; and
- (b) Prevent the lock from engaging in flight.

CS VLR.681 Limit load static tests

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

- (1) The direction of the test loads produces the most severe loading in the control system; and
- (2) Each fitting, pulley, and bracket used in attaching the system to the main structure is included.

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

CS VLR.683 Operation tests

It must be shown by operation tests that, when the controls are operated from the pilot compartment with the control system loaded to correspond with loads specified for the system, the system is free from-

- (a) Jamming;
- (b) Excessive friction; and
- (c) Excessive deflection.

CS VLR.685 Control system details

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

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

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

(d) Cable systems must be designed as follows:

(1) Cables, cable fittings, turnbuckles, splices and pulleys must be of an acceptable kind.

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

(3) No cable smaller than 2.38 mm (three thirty-seconds of an inch) diameter may be used in any primary control system.

(4) Pulley kinds and sizes must correspond to the cables with which they are used. (See AMC VLR.685(d)(4)).

(5) Pulleys must have close fitting guards to prevent the cables from being displaced or fouled.

(6) Pulleys must lie close enough to the plane passing through the cable to prevent the cable from rubbing against the pulley flange.

(7) No fairlead may cause a change in cable direction of more than 3°.

(8) No clevis pin subject to load or motion and retained only by cotter pins may be used in the control system.

(9) Turnbuckles attached to parts having angular motion must be installed to prevent binding throughout the range of travel.

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

(e) Control system joints subject to angular motion must incorporate the following special factors with respect to the ultimate bearing strength of the softest material used as a bearing:

- (1) 3.33 for push-pull system other than ball and roller bearing systems.
- (2) 2.0 for cable systems.

(f) For control system joints, the manufacturer's static, non-Brinell rating of ball and roller bearings must not be exceeded.

CS VLR.687 Spring devices

(a) Each control system spring device where failure could cause flutter or other unsafe characteristics must be reliable.

(b) Compliance with sub-paragraph (a) must be shown by test simulating service conditions.

CS VLR.691 Autorotation control mechanism

Each main rotor blade pitch control mechanism must allow rapid entry into autorotation after power failure.

LANDING GEAR

CS VLR.723 Shock absorption tests

The landing inertia load factor and the reserve energy absorption capacity of the landing gear must be substantiated by the tests prescribed in CS VLR.725 and 727, respectively or by analysis. These tests must be conducted on the complete rotorcraft or on undecarriage units in their proper relation.

CS VLR.725 Limit drop test
(See AMC VLR.725)

The limit drop test must be conducted as follows:

- (a) The drop height must be-
 - (1) 330 mm (13 inches) from the lowest point of the landing gear to the ground; or
 - (2) Any lesser height, not less than 203 mm (8 inches), resulting in a drop contact velocity equal to the greatest probable sinking speed likely to occur at ground contact in normal power-off landings.

(b) If considered, the rotor lift specified in CS VLR.473(a) must be introduced into the drop test by appropriate energy absorbing devices or by the use of an effective mass.

(c) Each landing gear unit must be tested in the attitude simulating the landing condition that is most critical from the standpoint of the energy absorbed by it.

(d) When an effective mass is used in showing compliance with sub-paragraph (b), the following formula may be used instead of more rational computations:

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

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

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

W = (kg), equal to the static reaction on the undecarriage unit with the rotorcraft in the most critical attitude. A rational method may be used in computing the reaction, taking into consideration the moment arm between the undecarriage reaction and the rotorcraft centre of gravity.

h = specified free drop height (mm).

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

d = the vertical component of the landing gear travel (mm) relative to the drop mass.

n = limit inertia load factor.

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

CS VLR.727 Reserve energy absorption drop test

The reserve energy absorption drop test must be conducted as follows:

- (a) The drop height must be 1.5 times that specified in CS VLR.725(a).
- (b) Rotor lift, where considered in a manner similar to that prescribed in CS VLR.725(b), may not exceed 1.5 times the lift allowed under that sub-paragraph.
- (c) The landing gear must withstand this test without collapsing. Collapse of the landing gear occurs when a member of the nose, tail, or main gear will not support the rotorcraft in the proper attitude or allows the

rotorcraft structure, other than the landing gear and external accessories, to impact the landing surface.

CS VLR.737 Skis

The maximum limit load rating of each ski must equal or exceed the maximum limit load determined under the applicable ground load requirements of this CS-VLR.

FLOATS AND HULLS

CS VLR.751 Main float buoyancy

(a) For main floats, the buoyancy necessary to support the maximum weight of the rotorcraft in fresh water must be exceeded by-

- (1) 50 %, for single floats; and
- (2) 60 %, for multiple floats.

(b) Each main float must have enough watertight compartments so that, with any single main float compartment flooded, the main floats will provide a margin of positive stability great enough to minimize the probability of capsizing.

CS VLR.753 Main float design

(a) *Bag floats.* Each bag float must be designed to withstand-

(1) The maximum pressure differential that might be developed at the maximum altitude for which certification with that float is requested; and

(2) The vertical loads prescribed in CS VLR.521(a), distributed along the length of the bag over three-quarters of its projected area.

(b) *Rigid floats.* Each rigid float must be able to withstand the vertical, horizontal, and side loads prescribed in CS VLR.521. These loads may be distributed along the length of the float.

PERSONNEL AND CARGO ACCOMMODATIONS

CS VLR.771 Pilot compartment

For each compartment-

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

(b) If there is provision for a second pilot, the rotorcraft must be controllable with equal safety from either pilot seat; and

(c) The vibration and noise characteristics of cockpit appurtenance may not interface with safe operation.

CS VLR.773 Pilot compartment view

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

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

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

CS VLR.775 Windshields and windows

Windshields and windows must be made of material that will not break into dangerous fragments.

CS VLR.777 Cockpit controls (See AMC VLR.777)

Cockpit controls must be-

(a) Located to provide convenient operation and to prevent confusion and inadvertent operation; and

(b) Located and arranged with respect to the pilots' seats so that there is full and unrestricted movement of each control without interference from the cockpit structure or the pilot's clothing when pilots from 157 cm to 180 cm in height are seated

CS VLR.779 Motion and effect of cockpit controls

Cockpit controls must be designed so that they operate in accordance with the following movements and actuation:

(a) Flight controls, including the collective pitch control, must operate with a sense of motion which corresponds to the effect on the rotorcraft.

(b) Twist-grip engine power controls must be designed so that, for lefthand operation, the motion of the pilot's hand is clockwise to increase power when the hand is viewed from the edge containing the index finger. Other engine power controls, excluding the collective control, must operate with a forward motion to increase power.

CS VLR.783 Doors

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

(b) Each external door must be located where persons using it will not be endangered by the rotors, propellers, engine intakes and exhausts when appropriate operating procedures are used. If opening procedures are required, they must be marked inside, on or adjacent to the door opening device.

CS VLR.785 Seats, safety belts, and harnesses

(a) Each seat and its supporting structure, must be designed for occupants weighing at least 86 kg, and for the maximum load factors corresponding to the specified flight and ground load conditions, including the emergency landing conditions prescribed in CS VLR.561.

(b) Each safety belt with shoulder harness, must be approved. Each safety belt with shoulder harness must be equipped with a metal to metal latching device.

(c) Each pilot seat must be designed for the reactions resulting from the application of pilot forces to the primary flight controls, as prescribed in CS VLR.397.

(d) Proof of compliance with a strength and deformation requirements of this paragraph for seats, approved as part of the type design and for seat installations may be shown by-

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

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

(3) Static load tests to ultimate loads.

(e) Each occupant must be protected from serious head injury when he experiences the inertia forces prescribed in CS VLR.561(b)(2) by a safety belt and shoulder harness that is designed to prevent the head

from contacting any injurious object. (See AMC VLR 785(e).)

(f) Each shoulder harness installed at a pilot seat must allow the pilot, when seated and with his safety belt and shoulder harness fastened, to perform all functions necessary for flight operations.

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

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

(i) The cabin area surrounding each seat, including the structure, interior walls, instrument panel, collective and cyclic controls, pedals, and seats, within striking distance of the occupant's head or torso (with the safety belt and shoulder harness fastened), must be free of potentially injurious objects, sharp edges, protuberances, and hard surface. If energy absorbing designs or devices are used to meet this requirement they must protect the occupant from serious injury when the occupant experiences the ultimate inertia forces prescribed in CS VLR.561(b)(3), and must not interfere with rapid evacuation of the rotorcraft.

CS VLR.787 Cargo and baggage compartments

(a) Each cargo and baggage compartment must be designed for its placarded maximum weight of contents and for the critical load distributions at the appropriate maximum load factors corresponding to specified flight and ground load conditions, except the emergency landing conditions of CS VLR.561.

(b) Under the emergency landing conditions of CS VLR.561, cargo and baggage compartments must have sufficient strength to withstand the conditions specified in CS VLR.561 including the means of restraint, and their attachments, required for the maximum weight of cargo and baggage at the critical loading distribution.

CS VLR 807 Emergency exits

(a) The cockpit must be designed to provide occupants with unimpeded and rapid escape in an emergency .

(b) Where the cockpit is enclosed, the opening system must be designed for simple and easy operation. It must function rapidly and be designed so that it can be operated by each occupant strapped in his/her seat and also from outside the cockpit. There must be reasonable provision to prevent jamming by fuselage deformation.

CS VLR.831 Ventilation

(a) The ventilating system for the pilot and passenger compartments must be designed to prevent the presence of excessive quantities of fuel fumes and carbon monoxide.

(b) The concentration of carbon monoxide may not exceed one part in 20,000 parts of air during forward flight or hovering in still air. If the concentration exceeds this value under other conditions, there must be suitable operating restrictions.

FIRE PROTECTION**CS VLR.853 Compartment interiors**

For the personnel compartment to be used by the crew or crew and passenger -

(a) The materials must be at least flash resistant.

(b) If smoking is to be prohibited, there must be a placard so stating, and if smoking is to be allowed there must be an adequate number of self-contained removable ashtrays.

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

(d) Rotorcraft materials located on the cabin side of the firewall must be self-extinguishing or be located at such a distance from the firewall, or otherwise protected, so that ignition will not occur if the firewall is subjected to a flame temperature of not less than 1100°C (2012°F) for 15 minutes. This may be shown by test or analysis. For self extinguishing materials (except electrical wire and cable insulation and small parts that the Agency finds would not contribute significantly to the propagation of a fire), a verticle self extinguishing test must be conducted in accordance with Appendix C or an equivalent method approved by the Agency. The average burn length of the material may not exceed 17 cm (6.7 inches) and the average flame time after removal of the flame source may not exceed 15 seconds. Drippings from the material test specimen may not continue to flame for more than an average of 3 seconds after falling.

CS VLR.855 Cargo and baggage compartments

(a) Each cargo and baggage compartment must be constructed of, or lined with, materials that are at least-

(1) Flame resistant in the case of compartments that are readily accessible to a crewmember in flight; and

(2) Fire resistant, in the case of other compartments.

(b) No compartment may contain any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operation, unless those items are protected so that-

(1) They cannot be damaged by the movement of cargo in the compartment; and

(2) Their breakage or failure will not create a fire hazard.

CS-VLR 857 Electrical bonding

(a) Electrical continuity must be provided to prevent the existence of difference of potential between components of the powerplant including fuel and other tanks, and other significant parts of the rotorcraft which are electrically conductive.

(b) There must be provisions for electrically bonding the rotorcraft to the ground fuelling equipment.

CS VLR.859 Heating systems

(a) *General.* For each heating system that involves the passage of cabin air over, or close to, the exhaust manifold, there must be means to prevent carbon monoxide from entering the personnel compartment.

(b) *Heat exchangers.* Each heat exchanger must be-

(1) Of suitable materials;

(2) Adequately cooled under all conditions; and

(3) Easily disassembled for inspection.

CS VLR.861 Fire protection of flight controls and flight structure

Each part of the structure, controls, rotor mechanism, and other parts essential to a controlled landing that would be affected by powerplant fires must be fireproof or protected so they can perform their essential functions for at least 5 minutes under any foreseeable powerplant fire conditions.

CS VLR.863 Flammable fluid fire protection

In each area where flammable fluids or vapours might escape by leakage of a fluid system, there must be means in the form of adequate segregation, ventilation and drainage, to minimize the probability of ignition of the fluids and vapours, and the resultant hazards if ignition does occur.

MISCELLANEOUS**CS VLR.871 Levelling marks**

There must be reference marks for leveling the rotorcraft on the ground.

CS VLR.873 Ballast provisions

Ballast provisions must be designed and constructed to prevent inadvertent shifting of ballast in flight.

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SUBPART E- POWERPLANT**GENERAL****CS VLR.901 Installation**

(a) For the purpose of this part, the powerplant installation includes each part of the rotorcraft (other than the main and auxiliary rotor structures) that -

- (1) Is necessary for propulsion;
 - (2) Affects the control of the propulsive unit;
- or
- (3) Affects the safety of the propulsive unit between normal inspections or overhauls.

(b) For the powerplant and its installation -

(1) Each component of the powerplant and its installation must be constructed, arranged, and installed to ensure its continued safe operation between normal inspections or overhauls for the range of temperature and altitude for which approval is requested;

(2) Accessibility must be provided to allow any inspection and maintenance necessary for continued airworthiness;

(3) Electrical interconnections must be provided to prevent differences of potential between major components of the installation and the rest of the rotorcraft;

(4) Design precautions must be taken to minimize the possibility of incorrect assembly of components and equipment essential to safe operation of the rotorcraft, except where operation with the incorrect assembly can be shown to be extremely improbable.

(See AMC VLR.901 (b).)

(c) The installation must comply with -

(1) The instructions for installing the engine required in the relevant code defined under CS VLR.903(a); and

(2) The applicable provisions of this Subpart.

(See AMC VLR 901 (c).)

CS VLR.903 Engine

(a) The engine must meet the specifications of Appendix B. (See AMC VLR.903(a).)

(b) *Engine or drive system cooling fan blade protection.*

(1) If an engine or rotor drive system cooling fan is installed, there must be a means to protect the rotorcraft and allow a safe landing if a fan blade fails. This must be shown by showing that -

(i) The fan blades are contained in case of failure;

(ii) Each fan is located so that a failure will not jeopardise safety; or

(iii) Each fan blade can withstand an ultimate load of 1.5 times the centrifugal force resulting from operation limited by the following:

(A) For fans driven directly by the engine--

(1) The terminal engine r.p.m. under uncontrolled conditions; or

(2) An over-speed limiting device.

(B) For fans driven by the rotor drive system, the maximum rotor drive system rotational speed to be expected in service, including transients.

(2) Unless a fatigue evaluation under CS VLR.571 is conducted, it must be shown that cooling fan blades are not operating at resonant conditions within the operating limits of the rotorcraft.

CS VLR.907 Engine vibration

(a) The engine must be installed to prevent the harmful vibration of any part of the engine or rotorcraft.

(b) The addition of the rotor and the rotor drive system to the engine must not subject the principal rotating parts of the engine to excessive vibrations or vibration stresses (see AMC VLR 907).

(c) No part of the rotor drive system may be subjected to excessive vibration stresses.

ROTOR DRIVE SYSTEM

CS VLR.917 Design

(a) Each rotor drive system must incorporate a unit to automatically disengage the engine from the main and auxiliary rotors if that engine fails.

(b) Each rotor drive system must be arranged so that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(c) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(d) The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gear boxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

CS VLR.921 Rotor brake

If there is a means to control the rotation of the rotor drive system independently of the engine, any limitations on the use of that means must be specified, and the control for that means must be guarded to prevent inadvertent operation.

CS VLR.923 Rotor drive system and control mechanism tests

(a) Each part tested as prescribed in this paragraph must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(b) Each rotor drive system and control mechanism must be tested for not less than 100 hours. The test must be conducted on the rotorcraft, and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(c) A 60-hour part of the test prescribed in sub-paragraph (b) must be run at not less than maximum continuous torque and the maximum speed for use with maximum continuous torque. In this test, the main rotor controls must be set in the position that will give

maximum longitudinal cyclic pitch change to simulate forward flight. The auxiliary rotor controls must be in the position for normal operation under the conditions of the test.

(d) A 30-hour part of the test prescribed in sub-paragraph (b) must be run at not less than 75 % of maximum continuous torque and the minimum speed for use with 75 % of maximum continuous torque. The main and auxiliary rotor controls must be in the position for normal operation under the conditions of the test.

(e) A 10-hour part of the test prescribed in sub-paragraph (b) must be run at not less than take-off torque and the maximum speed for use with take-off torque. The main and auxiliary rotor controls must be in the normal position for vertical ascent.

(f) The parts of the test prescribed in sub-paragraphs (c) and (d) must be conducted in intervals of not less than 30 minutes and may be accomplished either on the ground or in flight. The part of the test prescribed in sub-paragraph (e) must be conducted in intervals of not less than 5 minutes.

(g) At intervals of not more than five hours during the tests prescribed in sub-paragraphs (c), (d) and (e), the engine must be stopped rapidly enough to allow the engine and rotor drive to be automatically disengaged from the rotors.

(h) Under the operating conditions specified in sub-paragraph (c), 500 complete cycles of lateral control, 500 complete cycles of longitudinal control of the main rotors, and 500 complete cycles of control of each auxiliary rotor must be accomplished. A "complete cycle" involves movement of the controls from the neutral position, through both extreme positions, and back to the neutral position, except that control movements need not produce loads or flapping motions exceeding the maximum loads or motions encountered in flight. The cycling may be accomplished during the testing prescribed in sub-paragraph (c).

(i) At least 200 start-up clutch engagements must be accomplished-

(1) So that the shaft on the driven side of the clutch is accelerated; and

(2) Using a speed and method selected by the applicant.

CS VLR.927 Additional tests

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) It must be shown by tests that the rotor drive system is capable of operating under autorotative conditions for 15 minutes after the loss of pressure in the rotor drive primary oil system.

CS VLR.931 Shafting critical speed

(a) The critical speeds of any shafting must be determined by demonstration, except that analytical methods may be used if reliable methods of analysis are available for the particular design.

(b) If any critical speed lies within, or close to, the operating ranges for idling, power-on, and autorotative conditions, the stresses occurring at that speed must be within safe limits. This must be shown by tests.

(c) If analytical methods are used and show that no critical speed lies within the permissible operating ranges, the margins between the calculated critical speeds and the limits of the allowable operating ranges must be adequate to allow for possible variations between the computed and actual values.

CS VLR.935 Shafting joints

Each universal joint, slip joint, and other shafting joints whose lubrication is necessary for operation must have provision for lubrication.

FUEL SYSTEM

CS VLR.951 General

(a) Each fuel system must be constructed and arranged to ensure a flow of fuel at a rate and pressure established for proper engine functioning under any normal operating condition and must be arranged to minimise the occurrence of vapour lock and to prevent introducing air into the system.

(b) The fuel system must be arranged so that no fuel pump can draw fuel from more than one tank at a time. Gravity feed systems must not supply fuel to the engine from more than one tank at a time, unless the airspaces are interconnected in a manner to ensure that all interconnected tanks feed equally.

(c) Each fuel system for a compression ignition engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 27°C (80°F) and having 0.198 cc of free water per litre (0.75 cc per US gallon, 0.899 cc per Imperial gallon) added and cooled to the most critical condition for icing likely to be encountered in operation.

CS VLR.955 Fuel flow

(a) *General.* The ability of the fuel system to provide fuel at the rates specified in this paragraph and at a pressure sufficient for proper carburettor or fuel injector operation must be shown in the attitude that is most critical with respect to fuel feed and quantity of unusable fuel. These conditions may be simulated in a suitable mock-up. In addition:-

(1) The quantity of fuel in the tank may not exceed the amount established as the unusable fuel supply for that tank under CS VLR.959 plus that necessary to show compliance with this paragraph; and

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

(3) The fuel filter required by CS VLR. 977 must be blocked to other degree necessary to provide the highest foreseeable pressure across the filter.

(b) *Gravity Systems.* The fuel flow rate for gravity systems (main and reserve supply) must be 150% of the take-off fuel consumption of the engine.

(c) *Pump Systems.* The fuel flow rate for each pump system (main and reserve supply) must be 125% of the take-off fuel consumption of the engine at the maximum power established for take-off. This flow rate is required for each primary engine-driven pump and each emergency pump, and must be available when the pump is running as it would during take-off.

(d) *Multiple fuel tanks.* If the engine can be supplied with fuel from more than one tank, it must be possible, in level flight, to regain full power and fuel pressure to that engine in not more than 10 seconds after switching to any full tank after engine malfunctioning due to fuel depletion becomes apparent while the engine was being supplied from any other tank.

CS VLR.959 Unusable fuel supply

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

CS VLR.961 Fuel system hot weather operation

Each suction lift fuel system and other fuel systems with features conducive to vapour formation must be shown by test to operate satisfactorily (within

certification limits) when using fuel at a temperature of 43°C (110° F) .

CS VLR.963 Fuel tanks: general

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

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

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

(d) The maximum exposed surface temperature of any component in the fuel tank must be less, by a safe margin, than the lowest expected auto-ignition temperature of the fuel or fuel vapour in the tank. Compliance with this requirement must be shown under all operating and all failure or malfunction conditions of all components inside the tank.

CS VLR.965 Fuel tank tests

Each fuel tank must be able to withstand the following pressure without failure or leakage:

(a) For each conventional metal tank and nonmetallic tank with walls not supported by the rotorcraft structure, a pressure of 24 kPa.

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

(c) For each nonmetallic tank with walls supported by the rotorcraft structure and constructed in an acceptable manner using acceptable basic tank material, and with actual or simulated support conditions, a pressure of 14 kPa, for the first tank of a specific design. The supporting structure must be designed for the critical loads occurring in the flight or landing strength conditions combined with the fuel pressure loads resulting from the corresponding accelerations.

CS VLR.967 Fuel tank installation

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

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

(2) Padding must be non-absorbent or treated to prevent the absorption of fuel;

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

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

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

(ii) The construction of the liner itself provides such protection.

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

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

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

(c) No fuel tank may be on the engine side of the firewall. There must be at least 13 mm of clearance between the fuel tank and the firewall. No part of the engine nacelle skin that lies immediately behind a major air opening from the engine compartment may act as the wall of an integral tank.

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

(e) Fuel tanks, fuel tank components and fuel system components must be designed, located, and installed so as to retain fuel under the inertia forces prescribed for the emergency landing conditions in CS VLR.561.

CS VLR.969 Fuel tank expansion space

Each fuel tank must have an expansion space of not less than 2 % of the tank capacity, unless the tank vent discharges clear of the rotorcraft (in which case no expansion space is required). It must be impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

CS VLR.971 Fuel tank sump

(a) Each fuel tank must have a sump with an effective capacity, in the normal ground and flight attitudes, of 0.10 % of the tank capacity or 120 cm³, whichever is greater, unless-

(1) The fuel system has a sediment bowl or chamber that is accessible for drainage and has a capacity of 25 cm³

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

(b) Each sump, sediment bowl, and sediment chamber drain required by sub-paragraph (a) must comply with the drain provisions of CS VLR.999(b)(1)(2) and (3).

CS VLR.973 Fuel tank filler connection

(a) Fuel tank filler connection must be located outside the personnel compartment. Spilled fuel must be prevented from entering the fuel tank compartment or any part of the rotorcraft other than the tank itself.

(b) Each filler cap must provide a fuel-tight seal for the main filler opening. However, there may be small openings in the fuel tank cap for venting purposes or for the purpose of allowing passage of a fuel gauge through the cap.

CS VLR.975 Fuel tank vents and carburettor vapour vents

(a) Each fuel tank must be vented from the top part of the expansion space so that venting is effective under all normal flight conditions. Each vent must minimise the probability of stoppage by dirt or ice.

(b) The venting system must be designed to minimise spillage of fuel through vents to an ignition source in the event of a rollover during landing, ground operation, or a survivable impact

CS VLR.977 Fuel strainer and filter

(a) There must be a fuel filter between the tank outlet and the carburettor inlet or fuel injector. This fuel filter must -

(1) Have the capacity (with respect to operating limitations established for the engine) to ensure that engine fuel system functioning is not impaired, with the fuel contaminated to a degree (with respect to particle size and quantity) that is

greater than that established for the engine approval; and

(2) Be easily accessible for draining and cleaning.

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

(b) There must be a strainer at the outlet of each fuel tank. This strainer must-

(1) Have 3 to 6 meshes per centimeter;

(2) Have a length of at least twice the diameter of the fuel tank outlet;

(3) Have a diameter of at least that of the fuel tank outlet; and

(4) Be accessible for inspection and cleaning.

FUEL SYSTEM COMPONENTS**CS VLR.991 Fuel pumps**

(a) Compliance with CS VLR.955 may not be jeopardised by failure of-

(1) Any one pump except pumps that are approved and installed as parts of a type certificated engine; or

(2) Any component required for pump operation except, for engine driven pumps, the engine served by that pump.

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

CS VLR.993 Fuel system lines and fittings

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

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

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

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

(e) There must be means to guard against inadvertent operation of each shutoff, and to make it possible for the crew to reopen it in flight after it has been closed.

(f) Each shutoff valve and its control must be designed, located, and protected to function properly under any condition likely to result from an engine fire.

CS VLR.995 Fuel valves

(a) There must be a positive, quick-acting valve to shut-off fuel to the engine.

(b) The control for this valve must be within easy reach of appropriate crewmembers.

(c) Where there is more than one source of fuel supply there must be means for independent feeding from each source.

(d) No shut-off valve may be on the engine side of any firewall.

(e) Fuel tank selector valves must: -

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

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

CS VLR.999 Fuel system drains

(a) There must be at least one accessible drain at the lowest point in each fuel system to completely drain the system with the rotorcraft in any ground attitude to be expected in service.

(b) Each drain required by sub-paragraph (a) must-

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

(2) Have manual or automatic means to assure positive closure in the off position; and

(3) Have a drain valve that is readily accessible and which can be easily opened and closed.

OIL SYSTEM

CS VLR.1011 Engine: General

(a) If an engine is provided with an independent oil system it must be capable of supplying the engine with an appropriate quantity of oil at a temperature not exceeding the maximum established as safe for continuous operation.

(b) Each oil system must have a usable capacity adequate for the endurance of the rotorcraft.

(c) If an engine depends upon a fuel/oil mixture for lubrication, then a reliable means of providing it with the appropriate mixture must be established. (See AMC VLR.1011(c).)

CS VLR.1013 Oil tanks

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

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

(2) Padding must be non-absorbent or treated to prevent the absorption of oil;

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

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

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

(ii) The construction of the liner itself provides such protection.

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

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

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

(b) Each tank compartment must be ventilated and drained to prevent the accumulation of flammable fluids

or vapours. Each compartment adjacent to a tank that is an integral part of the rotorcraft structure must also be ventilated and drained.

(c) The oil level must be easy to check without having to remove any cowling parts (with the exception of oil tank access covers) or having to use any tools.

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

(e) If the oil tank is installed in the engine compartment it must be made of fireproof material except that, if the total oil capacity of the system including tanks, lines and sumps is less than 5 litres, it may be made of fire resistant material.

CS VLR.1015 Oil tank tests

Each oil tank must be able to withstand the following pressure without leakage :

(a) For each conventional metal tank and nonmetallic tank with walls not supported by the rotorcraft structure, a pressure of 35 kPa.

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

(c) For each nonmetallic tank with walls supported by the rotorcraft structure and constructed in an acceptable manner using acceptable basic tank material, and with actual or simulated support conditions, a pressure of 14 kPa, for the first tank of a specific design. The supporting structure must be designed for the critical loads occurring in the flight or landing strength conditions combined with the oil pressure loads resulting from the corresponding accelerations.

CS VLR.1017 Oil lines and fittings

(a) Oil lines must comply with the fuel system requirements of CS VLR. 993.

(b) *Breather lines.* Breather lines must be arranged so that-

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

(2) The breather discharge will not constitute a fire hazard if foaming occurs;

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

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

CS VLR.1019 Oil strainer or filter

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

CS VLR.1021 Oil system drains

A drain (or drains) must be provided to allow safe drainage of the oil system. Each drain must -

(a) Be accessible; and

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

CS VLR.1027 Transmissions and gearboxes: general

(a) Pressure lubrication systems for transmissions and gearboxes must comply with the engine oil system requirements of CS VLR.1013, -1015, -1017, -1021 and -1337(d).

(b) Each pressure lubrication system must have an oil strainer or filter through which all of the lubricant flows and must -

(1) Be designed to remove from the lubricant any contaminant which may damage transmission and drive system components or impede the flow of lubricant to a hazardous degree;

(2) Be equipped with a means to indicate collection of contaminations of the filter or strainer at or before opening of the bypass required by subparagraph (b)(3); and

(3) Be equipped with a bypass constructed and installed so that-

(i) The lubricant will flow at the normal rate through the rest of the system with the strainer or filter completely blocked; and

(ii) The release of collected contaminants is minimised by appropriate location of the bypass to ensure that collected contaminants are not in the bypass flowpath.

(c) For each lubricant tank or sump outlet supplying lubrication to rotor drive system and rotor drive system components, a screen must be provided to prevent entrance into the lubrication system of any object that might obstruct the flow of lubricant from the outlet to the filter required by sub-paragraph (b). The requirements of sub-paragraph (b) do not apply to screens installed at lubricant tank or sump outlets.

(d) Splash-type lubrication systems for rotor drive system gearboxes must comply with CS VLR.1021 and -1337(d).

COOLING

CS VLR.1041 General

(a) Each powerplant cooling system must be able to maintain the temperatures of powerplant components within the limits established for these components under critical operating conditions for which certification is required and after normal shutdown. Powerplant components to be considered include but may not be limited to engines, rotor drive system components, and the cooling or lubricating fluids used with these components.

(b) Compliance with sub-paragraph (a) must be shown in tests conducted under the conditions prescribed in that paragraph.

CS VLR.1043 Cooling tests

(a) *General.* For the tests prescribed in CS VLR.1041(b), the following apply:

(1) If the tests are conducted under conditions deviating from the maximum ambient atmospheric temperature specified in sub-paragraph (b), the recorded powerplant temperatures must be corrected under sub-paragraphs (c) and (d) unless a more rational correction method is applicable.

(2) No corrected temperature determined under sub-paragraph (a)(1) may exceed established limits.

(3) The fuel used during the cooling tests must be of the minimum grade approved for the engines, and the mixture settings must be those normally used in the flight stages for which the cooling tests are conducted.

(4) The test procedures must be as prescribed in CS VLR.1045.

(b) *Maximum ambient atmospheric temperature.* A maximum ambient atmospheric temperature

corresponding to sea-level conditions of at least 38°C (100°F) must be established. The assumed temperature lapse rate is 1.98°C (3.6°F) per 305m (1000ft) of altitude above sea-level until a temperature of -56.5°C (-69.7°F) is reached, above which altitude the temperature is considered constant at -56.5°C (-69.7°F). However, for winterization installations, the applicant may select a maximum ambient atmospheric temperature corresponding to sea level conditions of less than 38°C (100°F).

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

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

CS VLR.1045 Cooling test procedures

(a) *General.* For each stage of flight, the cooling tests must be conducted with the rotorcraft-

(1) In the configuration most critical for cooling; and

(2) Under the conditions most critical for cooling.

(b) *Temperature stabilization.* For the purpose of the cooling tests, a temperature is "stabilized" when its rate of change is less than 1°C (1.8°F) per minute. The following component and engine fluid temperature stabilization rules apply:

(1) For each rotorcraft, and for each stage of flight -

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

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

(2) For each rotorcraft during the take-off stage of flight, the climb at take-off power must be preceded by a period of hover during which the temperatures are stabilized.

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

- (1) The temperatures stabilise or 5 minutes after the occurrence of the highest temperature recorded, as appropriate to the test condition;
- (2) That stage of flight is completed; or
- (3) An operating limitation is reached.

LIQUID COOLING

CS VLR.1061 Installation

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

- (1) Each coolant tank is supported so that tank loads are distributed over a large part of the tank surface;
- (2) There are pads between the tank and its supports to prevent chafing. Padding must be non-absorbent or must be treated to prevent the absorption of flammable fluids; and
- (3) No air or vapour can be trapped in any part of the system, except the expansion tank, during filling or during operation.

(b) *Coolant tank*

- (1) Each coolant tank must be able to withstand the vibration, inertia, and fluids loads to which it may be subjected in operation.
- (2) Each coolant tank must have an expansion space of at least 10% of the total cooling system in the normal ground attitude.
- (3) It must be impossible to fill the expansion space inadvertently with the rotorcraft in the normal ground attitude.

(c) *Filler connection.* Each coolant tank filler connection must be marked as specified in CS VLR. 1557 (c). In addition -

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

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

(d) *Lines and fitting.* Each coolant system line and fitting must comply with the fuel system line requirements of CS VLR. 993, except that the inside diameter of the engine coolant inlet and outlet lines may not be less than the diameter of the corresponding engine inlet and outlet connections.

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

- (1) Each radiator must be supported to allow expansion due to operating temperatures and prevent the transmittal of harmful vibration to the radiator; and
- (2) If flammable coolant is used, the air intake duct to the coolant radiator must be located so that (in case of fire) flames from the nacelle cannot strike the radiator.

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

- (1) Drains the entire cooling system (including the coolant tank, radiator, and the engine) when the rotorcraft is in the normal ground attitude;
- (2) Discharges clear of the entire rotorcraft; and
- (3) Has means to positively lock it closed.

CS VLR.1063 Coolant tank test

Each coolant tank must comply with the fuel tank test requirements of CS VLR. 965, except that the test required by CS VLR. 965 (a) must be replaced with a similar test using the sum of the pressure developed during the maximum ultimate acceleration with a full tank or a pressure of 24 kPa, whichever is greater, plus the maximum working pressure of the system

INDUCTION SYSTEM

CS VLR.1091 Air induction

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

(b) Each cold air induction system opening must be outside the cowling if backfire flames can emerge.

(c) If fuel can accumulate in any air induction system, that system must have drains that discharge fuel-

- (1) Clear of the rotorcraft; and
- (2) Out of the path of exhaust flames.

CS VLR.1093 Induction system icing protection

(a) *Reciprocating and rotary engine.* The engine air induction system must have means to prevent and eliminate icing. Unless this is done by other means, it must be shown that, in air free of visible moisture at a temperature of -1°C (30°F) and with the engine at 75 % of maximum continuous power-

(1) Each rotorcraft with a sea-level engine using conventional venturi carburetors has a preheater that can provide a heat rise of 50°C (90 °F);

(2) Each rotorcraft with a sea-level engine using carburetors tending to prevent icing has a sheltered alternate source of air, and that the preheat supplied to the alternate air intake is not less than that provided by the engine cooling air downstream of the cylinders;

(3) Each rotorcraft with an altitude engine using conventional venturi carburetors has a preheater capable of providing a heat rise of 67 °C (120 °F); and

(4) Each rotorcraft with an altitude engine using carburetors tending to prevent icing has a preheater that can provide a heat rise of-

(i) 56 °C (100 °F); or

(ii) If a fluid de-icing system is used, at least 22 °C (40 °F).

(b) *Supercharged reciprocating and rotary engine.* For an engine having a supercharger to pressurize the air before it enters the carburettor, the heat rise in the air caused by that supercharging at any altitude may be utilised in determining compliance with sub-paragraph (a) if the heat rise utilised is that which will be available, automatically, for the applicable altitude and operating condition because of supercharging.

EXHAUST SYSTEM

CS VLR.1121 General

For each exhaust system -

(a) There must be means for thermal expansion of manifolds and pipes;

(b) There must be means to prevent local hot spots;

(c) Exhaust gases must discharge clear of the engine air intake, fuel system components, and drains;

(d) Each exhaust system part with a surface hot enough to ignite flammable fluids or vapours must be located or shielded so that leakage from any system carrying flammable fluids or vapours will not result in a fire caused by impingement of the fluids or vapours on any part of the exhaust system including shields for the exhaust system.

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

CS VLR.1123 Exhaust piping

(a) Exhaust piping must be heat and corrosion resistant, and must have provisions to prevent failure due to expansion by operating temperatures.

(b) Exhaust piping must be supported to withstand any vibration and inertia loads to which it would be subjected in operations.

(c) Exhaust piping connected to components between which relative motion could exist must have provisions for flexibility.

POWERPLANT CONTROLS AND ACCESSORIES

CS VLR.1141 Powerplant controls: general

(a) Powerplant controls must be located and arranged under CS VLR.777 and marked under CS VLR.1555.

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

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

(1) Constant attention; or

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

(d) Controls of powerplant valves required for safety must have-

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

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

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

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

CS VLR.1143 Engine controls

(a) The power or supercharger control must give a positive and immediate responsive means of controlling its engine or supercharger.

(b) If a power control incorporates a fuel shut-off feature, the control must have a means to prevent the inadvertent movement of the control into the shut-off position. The means must -

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

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

CS VLR.1145 Ignition switches

(a) Each ignition circuit must be independently switched, and must not require the operation of any other switch for it to be made operative.

(b) Ignition switches must be arranged and designed to prevent inadvertent operation.

(c) The ignition switch must not be used as the master switch for other circuits.

CS VLR.1147 Mixture control

The control must require a separate and distinct operation to move the control toward lean or shut-off position.

CS VLR.1151 Rotor brake controls

(a) It must be impossible to apply the rotor brake inadvertently in flight.

(b) There must be means to warn the crew if the rotor brake has not been completely released before take-off.

CS VLR.1163 Powerplant accessories

(a) Each engine-driven accessory must-

(1) Be satisfactory for mounting on the engine concerned;

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

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

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

(c) Unless other means are provided, torque limiting means must be provided for accessory drives located on any component of the transmission and rotor drive system to prevent damage to these components from excessive accessory load.

CS VLR.1165 Engine ignition systems

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

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

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

(1) The condition of an inoperative generator ;

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

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

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

POWERPLANT FIRE PROTECTION**CS VLR.1183 Lines, fittings, and components**

(a) Except as provided in sub-paragraph (b), each component, line, and fitting carrying flammable fluid in any area subject to engine fire conditions must be at least fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 23.7 litres (5.2 Imperial gallons/25-US quart) capacity on an engine need not be fireproof nor be enclosed by a fireproof shield.

(b) Sub paragraph (a) does not apply to-

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

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

(c) Each flammable fluid drain and vent must discharge clear of the induction system air inlet.

CS VLR.1185 Flammable fluids

(a) Each fuel tank must be isolated from the engines by a firewall or shroud.

(b) Each tank or reservoir, other than a fuel tank, that is part of a system containing flammable fluids or gases must be isolated from the engine by a firewall or shroud, unless the design of the system, the materials used in the tank and its supports, the shutoff means, and the connections, lines and controls provide a degree of safety equal to that which would exist if the tank or reservoir were isolated from the engine.

(c) There must be at least 13mm of clear airspace between each tank and each firewall or shroud isolating that tank, unless equivalent means are used to prevent heat transfer from each engine compartment to the flammable fluid.

CS VLR.1187 Ventilation

Each compartment containing any part of the powerplant installation must have provision for ventilation.

CS VLR.1191 Firewalls

(a) The engine must be isolated by a firewall, shroud, or equivalent means, from the personnel compartment, structures, controls, rotor mechanisms, and other parts that are-

(1) Essential to a controlled landing; and

(2) Not protected under CS-VLR 861;

(b) Reserved.

(c) In meeting sub-paragraph (a), account must be taken of the probable path of a fire as affected by the airflow in normal flight and in autorotation.

(d) Each firewall and shroud must be constructed so that no hazardous quantity of air, fluids, or flame can pass from any engine compartment to other parts of the rotorcraft.

(e) Each opening in the firewall or shroud must be sealed with close-fitting, fireproof grommets, bushings, or firewall fittings.

(f) Each firewall and shroud must be fireproof and protected against corrosion.

CS VLR.1193 Cowling and engine compartment covering

(a) Each cowling must be constructed and supported so that it can resist any vibration, inertia, and air loads to which it may be subjected in operation.

(b) There must be means for rapid and complete drainage of each part of the cowling in the normal ground and flight attitudes. No drain may discharge where it will cause a fire hazard.

(c) Cowling must be at least fire resistant.

(d) Each part behind an opening in the engine compartment cowling must be at least fire resistant for a distance of at least 60 cm aft of the opening.

(e) Each part of the cowling subjected to high temperatures due to its nearness to exhaust system ports or exhaust gas impingement, must be fireproof.

CS VLR.1194 Other Surfaces

All surfaces aft of, and near, powerplant compartments, other than tail surfaces not subject to heat, flames, or sparks emanating from a powerplant compartment, must be at least fire resistant.

SUBPART F – EQUIPMENT**GENERAL****CS VLR.1301 Function and installation**

Each item of installed equipment must –

- (a) Be of a kind and design appropriate to its intended function;
- (b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;
- (c) Be installed according to limitations specified for that equipment; and
- (d) Function properly when installed.

CS VLR.1303 Flight and navigation instruments

The following are the required flight and navigation instruments:

- (a) An airspeed indicator.
- (b) An altimeter.
- (c) A magnetic direction indicator.

CS VLR.1305 Powerplant instruments

The following are the required powerplant instruments:

- (a) A carburettor air temperature indicator, for each engine having a pre-heater that can provide a heat rise in excess of 33 °C (60°F).
- (b) A cylinder head temperature indicator for an:
 - (1) air cooled engine.
 - (2) Rotorcraft with cooling shutters,
 - (3) Rotorcraft for which compliance with CS VLR.1403 is shown in any condition other than the most critical flight condition with respect to cooling.

(See AMC VLR.1305(b).)

- (c) A low fuel pressure warning device except for fuel gravity system.

(d) A fuel quantity indicator, for each fuel tank. (See AMC VLR.1305 (d).)

(e) A manifold pressure indicator, for each altitude engine. (See AMC VLR.1305(e).)

(f) An oil temperature warning device to indicate when the temperature exceeds a safe value in main rotor drive gearbox having an oil system independent of the engine oil system.

(g) An oil pressure warning device to indicate when the pressure falls below a safe value in the pressure-lubricated main rotor drive gearbox.

(h) An oil pressure indicator for the engine.

(i) An oil quantity indicator for each oil tank.

(j) An oil temperature indicator for the engine.

(k) At least one tachometer to indicate the rpm of the engine and the rpm of the single main rotor;

(l) A low fuel warning device for each fuel tank which feeds the engine. This device must-

(1) Provide a warning to the flightcrew when approximately 10 minutes of useable fuel remains in the tank; and

(2) Be independent of the normal fuel quantity indicating system.

(m) Means to indicate to the flightcrew the failure of any fuel pump installed to show compliance with CS VLR.955.

(n) A coolant temperature indicator for a liquid-cooled engine.

(o) An indicator to indicate the proper functioning of any selectable or controllable heater used to prevent ice clogging of fuel system components.

CS VLR.1307 Miscellaneous equipment

The following is the required miscellaneous equipment:

(a) A seat for each occupant.

(b) A safety belt for each occupant.

(c) A master switch arrangement.

(d) An adequate source of electrical energy, where electrical energy is necessary for operation of the rotorcraft.

(e) Electrical protective devices.

CS VLR.1309 Equipment, systems, and installations

(a) The equipment, systems, and installations whose functioning is required by this Subpart must be designed and installed to ensure that they perform their intended functions under any foreseeable operating condition.

(b) The equipment, systems, and installations of the rotorcraft must be designed to minimise hazards to the rotorcraft in the event of a probable malfunction or failure.

INSTRUMENTS: INSTALLATION

CS VLR.1321 Arrangement and visibility

(a) Each flight, navigation, and powerplant instrument must be clearly arranged and plainly visible to each pilot.

(b) Instrument panel vibration may not damage or impair the readability or accuracy of any instrument.

CS VLR.1322 Warning, caution, and advisory lights

If warning, caution or advisory lights are installed in the cockpit, they must, unless otherwise approved by the Agency, be -

(a) Red, for warning lights (lights indicating a hazard which may require immediate corrective action);

(b) Amber, for caution lights (lights indicating the possible need for future corrective action);

(c) Green, for safe operation lights; and

(d) Any other colour, including white, for lights not described in sub-paragraphs (a) through (c), provided the colour differs sufficiently from the colours prescribed in sub-paragraphs (a) to (c) to avoid possible confusion.

CS VLR.1323 Airspeed indicating system

(a) Each airspeed indicating instrument must be calibrated to indicate true airspeed (at sea-level with a standard atmosphere) with a minimum practicable instrument calibration error when the corresponding pitot and static pressures are applied.

(b) The airspeed indicating system must be calibrated in flight at forward speeds of 37 km/h (20 kts) and over.

(c) The airspeed indicator must indicate true airspeed, at sea level in a standard atmosphere, with a maximum pitot-static error of not more than the greater of

(1) $\pm 5\%$ percent of the calibrated airspeed; or

(2) ± 9.3 km/h (5 kts).

CS VLR.1325 Static pressure system

(a) Each instrument with static air case connections must be vented so that the influence of rotorcraft speed, the opening and closing of windows, airflow variation and moisture or other foreign matter, does not seriously affect its accuracy.

(b) The design and installation of a static pressure system must be such that-

(1) Positive drainage of moisture is provided;

(2) Chafing of the tubing, and excessive distortion or restriction at bends in the tubing, is avoided; and

(3) The materials used are durable, suitable for the purpose intended, and protected against corrosion.

CS VLR.1327 Magnetic direction indicator

(a) The magnetic direction indicator required must be installed so that its accuracy is not excessively affected by the rotorcraft's vibration or magnetic fields.

(b) The compensated installation must not have a deviation in level flight, greater than 10° on any heading except that when the radio is transmitting the deviation may exceed 10° but must not exceed 15° .

CS VRL.1331 Instruments using a power supply

For each rotorcraft-

- (a) Each gyroscopic instrument must derive its energy from power sources adequate to maintain its required accuracy at any speed above the best rate-of-climb speed;
- (b) Each gyroscopic instrument must be installed so as to prevent malfunction due to rain, oil and other detrimental elements; and
- (c) There must be a means to indicate the adequacy of the power being supplied to the instruments.

CS VLR.1337 Powerplant instruments

(a) Instruments and instrument lines

(1) Each powerplant instrument line must meet the requirements of CS VLR.961 and 993 .

(2) Each line carrying flammable fluids under pressure must -

- (i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and
- (ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each powerplant instrument that utilises flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) *Fuel quantity indicator.* Each fuel quantity indicator must be installed to clearly indicate to the flight crew the quantity of fuel in each tank in flight. In addition-

(1) Each fuel quantity indicator must be calibrated to read "zero" during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS VLR.959;

(2) 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, at least one fuel quantity indicator must be installed; and

(3) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage.

(c) *Fuel flowmeter system.* If a fuel flow meter system is installed, each metering component must have a means for bypassing the fuel supply if malfunction of that component severely restricts fuel flow.

(d) *Oil quantity indicator.* There must be means to indicate the quantity of oil in each tank on the ground (including during the filling of each tank).

(e) Rotor drive system transmissions and gearboxes utilising ferromagnetic materials must be equipped with chip detectors designed to indicate or reveal the presence of ferromagnetic particles resulting from damage or excessive wear. Chip detectors must be removable for inspection of the magnetic poles for metallic chips.

ELECTRICAL SYSTEMS AND EQUIPMENT

CS VLR.1351 General

(a) *Electrical system capacity.* Electrical equipment must be adequate for its intended use. In addition-

(1) Electric power sources, their transmission cables, and their associated control and protective devices must be able to furnish the required power at the proper voltage to each load circuit essential for safe operation; and

(2) Compliance with sub-paragraph (a)(1) must be shown by an electrical load analysis, or by electrical measurements that take into account the electrical loads applied to the electrical system in probable combinations and for probable durations.

(b) *Function.* For each electrical system, the following apply:

(1) Each system when installed, must be -

(i) Free from hazards in itself, in its method of operation, and in its effects on other parts of the rotorcraft; and

(ii) Protected from fuel, oil, water other detrimental substances, and mechanical damage.

(2) Electric power sources must function properly when connected in combination or independently, except that alternators may depend on a battery for initial excitation or for stabilisation.

(3) No failure or malfunction of any source may impair the ability of any remaining source to supply load circuits essential for safe operation, except that the operation of an alternator that depends on a battery for initial excitation or for

stabilisation may be stopped by failure of that battery.

(4) Each electric power source control must allow the independent operation of each source, except that controls associated with alternators that depend on a battery for initial excitation or for stabilisation need not break connection between the alternator and its battery.

(c) *Generating system.* There must be at least one generator if the system supplies power to load circuits essential for safe operation. In addition-

(1) Each generator must be able to deliver its continuous rated power;

(2) Generator voltage control equipment must be able to dependably regulate each generator output within rated limits;

(3) Each generator must have a reverse current cutout designed to disconnect the generator from the battery and from the other generators when enough reverse current exists to damage that generator.

(4) Each generator must have an overvoltage control designed and installed to prevent damage to the electrical system, or to equipment supplied by the electrical system, that could result if that generator were to develop an overvoltage condition; and

(5) There must be a means to give immediate warning to the pilot of a failure of any generator.

(d) *Instruments.* There must be a means to indicate to the pilot that the electrical power supplies are adequate for safe operation. For direct current systems, an ammeter in the battery feeder may be used.

(e) *Fire resistance.* Electrical equipment must be so designed and installed that in the event of a fire in the engine compartment, during which the surface of the firewall adjacent to the fire is heated to 1100°C for 5 minutes or to a lesser temperature substantiated by the applicant, the equipment essential to continued safe operation and located behind the firewall will function satisfactorily and will not create an additional fire hazard. This may be shown by test or analysis.

(f) *External power.* If provisions are made for connecting external power to the rotorcraft, and that external power can be electrically connected to equipment other than that used for engine starting, means must be provided to ensure that no external power supply having a reverse polarity, or reverse phase sequence, can supply power to the rotorcraft's electrical system.

CS VLR.1353 Storage battery design and installation

(a) Each storage battery must be designed and installed as prescribed in this paragraph.

(b) Safe cell temperatures and pressures must be maintained during any probable charging and discharging condition. No uncontrolled increase in cell temperature may result when the battery is recharged (after previous complete discharge) -

(1) At maximum regulated voltage or power;

(2) During a flight of maximum duration; and

(3) Under the most adverse cooling condition likely to occur in service.

(c) Compliance with sub-paragraph (b) must be shown by test or experience with similar batteries and installations.

(d) No explosive or toxic gases emitted by any battery in normal operation, or as the result of any probable malfunction in the charging system or battery installation, may accumulate in hazardous quantities within the rotorcraft.

(e) No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent essential equipment.

(f) Each nickel cadmium battery installation capable of being used to start an engine or auxiliary power unit must have provisions to prevent any hazardous effect on structure of essential systems that may be caused by the maximum amount of heat the battery can generate during a short circuit of the battery or its individual cells.

(g) Nickel cadmium battery installations capable of being used to start an engine or auxiliary power unit must have -

(1) A system to control the charging rate of the battery automatically so as to prevent battery overheating;

(2) A battery temperature sensing and over-temperature warning system with means for disconnecting the battery from its charging source in the event of an over-temperature condition; or

(3) A battery failure sensing and warning system with a means for disconnecting the battery from its charging source in the event of battery failure.

CS VLR.1357 Circuit protective devices

(a) Protective devices, such as fuses or circuit breakers, must be installed in each electrical circuit other than-

(1) The main circuits of starter motors; and

(2) Circuits in which no hazard is presented by their omission.

(b) A protective device for a circuit essential to flight safety may not be used to protect any other circuit.

(c) Each resettable circuit protective device ("trip free" device in which the tripping mechanism cannot be overridden by the operating control) must be designed so that -

(1) A manual operation is required to restore service after tripping; and

(2) If an overload or circuit fault exists, the device will open the circuit regardless of the position of the operating control.

(d) If the ability to reset a circuit breaker or replace a fuse is essential to safety in flight, that circuit breaker or fuse must be located and identified so that it can be readily reset or replaced in flight.

(e) If fuses are used, there must be one spare of each rating, or 50 % spare fuse of each rating, whichever is greater.

CS VLR.1361 Master switch arrangement

(a) There must be a master switch or switches arranged to allow ready disconnection of all electric power sources. The point of disconnection must be adjacent to the sources controlled by the switch.

(b) The master switch arrangement must be so installed that it is easily discernible and accessible to the pilot in flight.

CS VLR.1365 Electric cables

(a) Each electric connecting cable must be of adequate capacity and correctly routed, attached and connected so as to minimise the probability of short circuits and fire hazards.

(b) Each cable and associated equipment that would overheat in the event of circuit overload or fault must be at least flame resistant and may not emit dangerous quantities of toxic fumes.

CS VLR.1367 Switches

Each switch must be-

(a) Able to carry its rated current;

(b) Accessible to the pilot; and

(c) Labelled as to operation and the circuit controlled.

LIGHTS**CS VLR.1384 External lights**

If external lights are installed then they must comply with paragraphs 27.1385 to 27.1401 of CS-27 as appropriate.

SAFETY EQUIPMENT**CS VLR.1411 General**

(a) When safety equipment is installed it must be readily accessible; and

(b) Stowage provisions for that equipment must be furnished and must -

(1) Be arranged so that the equipment is directly accessible and its location is obvious; and

(2) Protect the safety equipment from damage caused by being subjected to the inertia loads specified in CS VLR.561.

MISCELLANEOUS EQUIPMENT**CS VLR.1431 Electronic equipment**

Electronic equipment and installations must be free from hazards in themselves, in their method of operation, and in their effects on other components.

CS VLR.1461 Equipment containing high-energy rotors

(a) Equipment containing high-energy rotors must meet sub-paragraphs (b), (c), or (d).

(b) High-energy rotors contained in equipment must be able to withstand damage caused by malfunctions, vibration, abnormal speeds, and abnormal temperatures. In addition -

(1) Auxiliary rotor cases must be able to contain damage caused by the failure of high energy rotor blades; and

(2) Equipment control devices, systems, and instrumentation must reasonably ensure that no operating limitations affecting the integrity of high-energy rotors will be exceeded in service.

(c) It must be shown by test that equipment containing high-energy rotors can contain any failure of a high energy rotor that occurs at the highest speed obtainable with the normal speed control devices inoperative.

(d) Equipment containing high-energy rotors must be located where rotor failure will neither endanger the occupants nor adversely affect continued safe flight.

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

GENERAL

CS VLR.1501 General

(a) Each operating limitation specified in CS VLR.1503 to 1525 and other limitations and information necessary for safe operation must be established.

(b) The operating limitations and other information necessary for safe operation must be made available to the crew members as prescribed in CS VLR.1541 to 1589.

OPERATING LIMITATIONS

CS VLR.1503 Airspeed limitations: general

(a) An operating speed range must be established.

(b) When airspeed limitations are a function of weight, weight distribution, altitude, rotor speed, power, or other factors, airspeed limitations corresponding with the critical combinations of these factors must be established.

CS VLR.1505 Never-exceed speed

(a) The never-exceed speed, V_{NE} , must be established so that it is-

- (1) Not less than 74 km/h (40 kts) (CAS); and
- (2) Not more than the lesser of-
 - (i) 0.9 times the maximum forward speeds established under CS VLR.309;
 - (ii) 0.9 times the maximum speed shown under CS VLR.251 and 629; or
 - (iii) 0.9 times the maximum speed substantiated for advancing blade tip mach number effects.

(b) V_{NE} may vary with altitude, rpm, temperature, and weight, if

- (1) No more than two of these variables (or no more than two instruments integrating more than one of these variables) are used at one time, and
- (2) The range of these variables (or of the indications on instruments integrating more than one

of these variables) are large enough to allow an operationally practical and safe variation of V_{NE} .

(c) For helicopters, a stabilized power-off V_{NE} denoted as V_{NE} (power-off) may be established at a speed less than V_{NE} established pursuant to subparagraph (a), if the following conditions are met:

(1) V_{NE} (power-off) is not less than a speed midway between the power-on V and the speed used in meeting the requirements of CS VLR.65(b).

(2) V_{NE} (power-off) is-

- (i) A constant airspeed;
- (ii) A constant amount less than power-on V_{NE} ;
- (iii) A constant airspeed for a portion of the altitude range for which certification is requested, and a constant amount less than power on V_{NE} for the remainder of the altitude range.

CS VLR.1509 Rotor speed

(a) *Maximum power-off (autorotation)*. The maximum power-off rotor speed must be established so that it does not exceed 95 % of the lesser of -

- (1) The maximum design rpm determined under CS VLR.309 (b); and
- (2) The maximum rpm shown during the type tests.

(b) *Minimum power-off*. The minimum power-off rotor speed must be established so that it is not less than 105 % of the greater of -

- (1) The minimum shown during the type tests; and
- (2) The minimum determined by design substantiation.

(c) *Minimum power-on*. The minimum power-on rotor speed must be established so that it is-

- (1) Not less than the greater of-
 - (i) The minimum shown during the type tests; and

(ii) The minimum determined by design substantiation; and

(2) Not more than a value determined under CS VLR.33 (a)(1) and (b)(1).

CS VLR.1519 Weight and centre of gravity

The weight and centre of gravity limitations determined under CS VLR.25 and 27, respectively, must be established as operating limitations.

CS VLR.1521 Powerplant limitations

(a) *General.* The powerplant limitations prescribed in this paragraph must be established so that they do not exceed the corresponding limits established for the engine.

(b) *Take-off operation.* The powerplant take-off operation must be limited by -

(1) The maximum rotational speed, which may not be greater than -

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The maximum allowable manifold pressure;

(3) The time limit for the use of the power corresponding to the limitations established in sub-paragraph (b)(1) and (2);

(4) If the time limit in sub-paragraph (b)(3) exceeds 2 minutes, the maximum allowable cylinder head, coolant outlet, or oil temperatures;

(c) *Continuous operation.* The continuous operation must be limited by-

(1) The maximum rotational speed which may not be greater than-

(i) The maximum value determined by the rotor design; or

(ii) The maximum value shown during the type tests;

(2) The minimum rotational speed shown under the rotor speed requirements in CS VLR.1509(c).

(d) *Fuel grade or designation.* The minimum fuel grade must be established so that is not less than that required for the operation of the engine within the limitations in sub-paragraph (b) and (c).

CS VLR.1525 Kinds of operation

The kinds of operation to which the rotorcraft is limited are established by the category in which it is eligible for certification and by the installed equipment.

CS VLR.1527 Maximum operating altitude

The maximum altitude up to which operation is allowed, as limited by flight, structural, powerplant, functional, or equipment characteristics, must be established.

CS VLR.1529 Instructions for Continued Airworthiness

Instructions for Continued Airworthiness in accordance with Appendix A must be prepared.

MARKINGS AND PLACARDS

CSVLR.1541 General

(a) The rotorcraft must contain-

(1) The markings and placards specified in CS VLR.1545 to CS VLR.1565, and

(2) Any additional information, instrument markings, and placards required for the safe operation of rotorcraft if it has unusual design, operating or handling characteristics.

(b) Each marking and placard prescribed in sub-paragraph (a) -

(1) Must be displayed in a conspicuous place; and

(2) May not be easily erased, disfigured, or obscured.

(c) The units of measurement used on placards must be the same as those used on the indicators.

CS VLR.1543 Instrument markings: general

For each instrument -

(a) When markings are on the cover glass of the instrument, there must be means to maintain the correct alignment of the glass cover with the face of the dial; and

(b) Each arc and line must be wide enough, and located, to be clearly visible to the pilot.

CS VLR.1545 Airspeed indicator

(a) Each airspeed indicator must be marked as specified in sub-paragraph (b), with the marks located at the corresponding indicated airspeeds.

(b) The following markings must be made:

(1) A red radial line-

(i) For rotorcraft other than helicopters, at V_{NE} ; and

(ii) For helicopters at V_{NE} (power-on).

(2) A red cross-hatched radial line at V_{NE} (power-off) for helicopters, if V_{NE} (power-off) is less than V_{NE} (power-on).

(3) For the caution range, a yellow arc.

(4) For the safe operating range, a green arc.

CS VLR.1547 Magnetic direction indicator

(a) A placard meeting the requirements of this section must be installed on or near the magnetic direction indicator.

(b) The placard must show the calibration of the instrument in level flight with the engines operating.

(c) The placard must state whether the calibration was made with radio receivers on or off.

(d) Each calibration reading must be in terms of magnetic heading in not more than 45 degree increments.

CS VLR.1549 Powerplant instruments

For each required powerplant instrument, as appropriate to the type of instrument -

(a) Each maximum and, if applicable, minimum safe operating limit must be marked with a red radial or a red line;

(b) Each normal operating range must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits;

(c) Each take-off and precautionary range must be marked with a yellow arc or yellow line;

(d) Each engine range that is restricted because of excessive vibration stresses must be marked with red arcs or red lines.

CS VLR.1551 Oil quantity indicator

Each oil quantity indicator must be marked with enough increments to indicate readily and accurately the quantity of oil.

CS VLR.1553 Fuel quantity indicator

If the unusable fuel supply for any tank exceeds 3.8 litres (0.8 Imperial gallon/1 US gallon), or 5 % of the tank capacity, whichever is greater, a red arc must be marked on its indicator extending from the calibrated zero reading to the lowest reading obtainable in level flight.

CS VLR.1555 Control markings

(a) Each cockpit control, other than primary flight controls or control whose function is obvious, must be plainly marked as to its function and method of operation.

(b) For powerplant fuel controls-

(1) Each fuel tank selector control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;

(2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on, or adjacent to, the selector for those tanks; and

(c) Useable fuel capacity must be marked as follows:

(1) For fuel systems having no selector controls, the useable fuel capacity of the system must be indicated at the fuel quantity indicator.

(2) For fuel systems having selector controls, the useable fuel capacity available at each selector

control position must be indicated near the selector control.

(d) For accessory, auxiliary, and emergency controls -

(1) Each essential visual position indicator, such as those showing rotor pitch, must be marked so that each crew member can determine at any time the position of the unit to which it relates; and

(2) Each emergency control must be red and must be marked as to method of operation.

CS VLR.1557 Miscellaneous markings and placards

(a) *Baggage and cargo compartments, and ballast location.* Each baggage and cargo compartment, and each ballast location must have a placard stating any limitations on contents, including weight, that are necessary under the loading requirements.

(b) *Fuel and oil filler openings.* The following apply:

(1) Fuel filler openings must be marked at or near the filler cover with the minimum fuel grade, fuel designation, fuel capacity of the tank, and for each 2-stroke engine without a separate oil system, fuel/oil mixture ratio.

(2) Oil filler openings must be marked at or near the filler cover;

(i) With the grade; and

(ii) If the oil is detergent or nondetergent.

(c) *Fuel tanks.* The useable fuel capacity in volumetric units of each tank must be marked at the selector and on the fuel quantity indicator.

(d) When an emergency exit is provided in compliance with CS VLR.807, each operating control must be red. The placards must be near each control and must clearly indicate its method of operation.

(e) The system voltage of each direct current installation must be clearly marked adjacent to its external power connection.

CS VLR.1559 Limitations placard

There must be a placard in clear view of the pilot that specifies the kinds of operations (VFR day, NO ICING) for which the rotorcraft is approved.

CS VLR.1561 Safety equipment

(a) When installed, safety equipment must be plainly marked as to method of operation; and

(b) Stowage provisions for that equipment must be marked for the benefit of occupants.

CS VLR.1565 Tail rotor

The tail rotor must be marked so that its disc is conspicuous under normal daylight ground conditions.

ROTORCRAFT FLIGHT MANUAL AND APPROVED MANUAL MATERIAL

CS VLR.1581 General

(a) *Furnishing information.* A Rotorcraft Flight Manual must be furnished with each rotorcraft, and it must contain the following:

(1) Information required by CS VLR.1583 through 1589.

(2) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) *Approved information.* Each part of the manual listed in CS VLR.1583 through 1589, that is appropriate to the rotorcraft, must be furnished, verified, and approved, and must be segregated, identified, and clearly distinguished from each unapproved part of that manual.

(c) *Non-approved Information.* Non-approved information must be presented in a manner acceptable to the Agency.

(d) *Units.* The units of measurement used in the manual must be the same as those used on the indicators.

(e) *Table of contents.* Each Rotorcraft Flight Manual must include a table of contents if the complexity of the manual indicates a need for it.

CS VLR.1583 Operating limitations

(a) *Airspeed and rotor limitations.* Information necessary for the marking of airspeed and rotor limitations on, or near, their respective indicators must be furnished. The significance of each limitation and of the colour coding must be explained.

(b) *Powerplant limitations.* The following information must be furnished:

(1) Limitations required by CS VLR.1521.

(2) Explanation of the limitations, when appropriate.

(3) Information necessary for marking the instruments required by CS VLR.1549 to 1553.

(4) For two-stroke engines, fuel/oil ratio.

(c) *Weight and loading distribution.* The weight and centre of gravity limits required by CS VLR.25 and 27, respectively, must be furnished. If the variety of possible loading warrants, instructions must be included to allow ready observance of the limitations.

(d) *Kinds of operation.* Each kind of operation for which the rotorcraft and its equipment installations are approved must be listed.

(e) *Altitude.* The altitude established under CS VLR.1527 and an explanation of the limiting factors must be furnished.

CS VLR.1585 Operating procedures

(a) Part of the manual containing operating procedures must have information concerning any normal and emergency procedures and other information necessary for safe operation, including take-off and landing procedures and associated airspeeds. The manual must contain any pertinent information including-

(1) The kind of take-off surface used in the tests and each appropriate climbout speed; and

(2) The kind of landing surface used in the tests and appropriate approach and glide airspeeds.

(b) For helicopters for which a V_{NE} (power-off) is established under CS VLR.1505(c), information must be furnished to explain the V_{NE} (power-off) and the procedures for reducing airspeed to not more than the V_{NE} (power-off) following failure of engine.

(c) For each rotorcraft showing compliance with CS VLR.1353 (g)(2) or (g)(3), the operating procedures

for disconnecting the battery from its charging source must be furnished.

(d) If the unusable fuel supply in any tank exceeds 5 % of the tank capacity, or 3.8 litres (0.8 Imperial gallon/ 1 US gallon), whichever is greater, information must be furnished which indicates that when the fuel quantity indicator reads "zero" in level flight, any fuel remaining in the fuel tank cannot be used safely in flight.

(e) Information on the total quantity of useable fuel for each fuel tank must be furnished.

(f) The airspeed and rotor speeds for minimum rate of descent and best glide angle as prescribed in CS VLR.71 must be provided.

CS VLR.1587 Performance information

(a) The rotorcraft must be furnished with the following information, determined in accordance with CS VLR.51 to 79 and 143 (c):

(1) Enough information to determine the limiting height-speed envelope.

(2) Information relative to -

(i) The hovering ceilings and the steady rates of climb and descent, as affected by any pertinent factors such as airspeed, temperature, and altitude;

(ii) The maximum safe wind for operation near the ground. If there are combinations of weight, altitude and temperature for which performance information is provided and at which the rotorcraft cannot land and take-off safely with the maximum wind value, those portions of the operating envelope and the appropriate safe wind conditions shall be identified in the flight manual.

(iii) The maximum atmospheric temperature at which compliance with the cooling provisions of CS VLR.1041 to -1045 is shown; and

(iv) Glide distance as a function of altitude when autorotating at the speeds and conditions for minimum rate of descent and best glide as determined in CS VLR.71.

(b) The Rotorcraft Flight Manual must contain in its performance information section any pertinent information concerning the take-off weights and altitudes used in compliance with CS VLR.51.

CS VLR.1589 Loading information

There must be loading instructions for each possible loading condition between the maximum and minimum weights determined under CS VLR.25 that can result in a centre of gravity beyond any extreme prescribed in CS VLR.27, assuming any probable occupant weights.

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APPENDICES

APPENDIX A

INSTRUCTIONS FOR CONTINUED AIRWORTHINESS

A.VLR.1 General

(a) This appendix specifies requirements for the preparation of instructions for continued airworthiness as required by CS VLR.1529.

(b) The instructions for continued airworthiness for each rotorcraft must include the instructions for continued airworthiness for each engine and rotor (hereinafter designated "products"), for each appliance required by any applicable CS or operating rule, and any required information relating to the interface of those appliances and products with the rotorcraft. If instructions for continued airworthiness are not supplied by the manufacturer of an appliance or product installed in the rotorcraft, the instructions for continued airworthiness for the rotorcraft must include the information essential to the continued airworthiness of the rotorcraft.

A.VLR.2 Format

(a) The instructions for continued airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

A.VLR.3 Content

The contents of the manual or manuals must be prepared in the English language. The instructions for continued airworthiness must contain the following manuals or paragraphs, as appropriate, and information:

(a) Rotorcraft maintenance manual or paragraph:

(1) Introduction information that includes an explanation of the rotorcraft's features and data to the extent necessary for maintenance.

(2) A description of the rotorcraft and its systems and installations including its engine, rotors, and appliances.

(3) Basic control and operation information describing how the rotorcraft components and systems are controlled and how they operate, including any special procedures and limitations that apply.

(4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing, locations of lubrication points, the lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and levelling information.

(b) Maintenance instructions

(1) Scheduling information for each part of the rotorcraft and its engines, auxiliary power units, rotors accessories, instruments and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances and work recommended at these periods. However, it is allowed to refer to an accessory, instrument or equipment manufacturer as the source of this information if it is shown that the item has an exceptionally high degree of complexity requiring specialized maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the airworthiness limitations paragraph of the manual must also be included. In addition, an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the rotorcraft must be included.

(2) Troubleshooting information describing problem malfunctions, how to recognize those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the centre of gravity, lifting and shoring, and storage limitations.

(c) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(d) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified.

(e) Information needed to apply protective treatments to the structure after inspection.

(f) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(g) A list of special tools needed.

A.VLR.4 Airworthiness Limitations Section

The instructions for continued airworthiness must contain a paragraph titled airworthiness limitations, that is segregated and clearly distinguishable from the rest of the document. This paragraph must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure approved under CS VLR.571. If the instructions for continued airworthiness consists of multiple documents, the paragraph required by this sub-paragraph must be included in the principal manual. This paragraph must contain a legible statement in a prominent location that reads:

"The airworthiness limitations section is approved and variations must also be approved".

APPENDIX B

ENGINES

B.VLR.1 Applicability
(See AMC B.VLR.1)

This appendix B is applicable to engines for very light rotorcraft (helicopters).

B.VLR.3 Instruction manual

Instructions for installing and operating the engine must be established. In particular, the following instructions must be included:

- (a) The operating limitations, including any relevant limitation on temperatures for cylinder heads, coolant outlet, oil.
- (b) The power ratings and procedures for correcting for non-standard atmosphere.
- (c) The recommended procedures, under normal and extreme ambient conditions for-
 - (1) Starting;
 - (2) Operating on the ground; and
 - (3) Operating during flight.
- (d) For two-stroke engines, fuel/oil ratio.

B.VLR.5 Engine power ratings and operating limitations

Engine power ratings and operating limitations must be based on the operating conditions demonstrated during the tests prescribed in this appendix B. They include limitations relating to speeds, temperatures, pressures, fuels and oils which the applicant finds necessary for the safe operation of the engine.

B.VLR.7 Selection of Engine power ratings

- (a) Requested engine power ratings must be selected by the applicant.
- (b) Each selected rating must be for the lowest power that all engines of the same type may be expected to produce under the conditions used to determine that rating.

B.VLR.9 Engine Critical Parts

(a) A critical part is a part, the failure of which could have a catastrophic effect upon the rotorcraft, and for which critical characteristics have been identified which must be controlled to ensure the required level of integrity.

(b) If the engine type design includes critical parts, a critical parts list must be established. Procedures must be established to define the critical design characteristics, identify processes that affect those characteristics, and identify the design change and process change controls necessary for showing compliance with the quality assurance requirements of Part 21.

B.VLR.11 Materials

The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must-

- (a) Be established on the basis of experience or tests;
- (b) Meet approved specifications that ensure their having the strength and other properties assumed in the design data; and
- (c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.

B.VLR.13 Fabrication methods

- (a) The methods of fabrication used must produce consistently sound structures. If a fabrication process (such as gluing, spot welding, or heat-treating) requires close control to reach this objective, the process must be performed according to an approved process specification.
- (b) Each new fabrication method must be substantiated by a test programme.

B.VLR.15 Fasteners

(a) Each removable bolt, screw, nut, pin or other fastener whose loss could jeopardise the safe operation of the engine must incorporate two separate locking devices. The fastener and its locking devices may not be adversely affected by the environmental conditions associated with the particular aircraft installation.

(b) No self-locking nut may be used on any bolt subject to rotation in operation unless a non-friction locking device is used in addition to the self-locking device.

B.VLR.17 Protection of structure

Each part of the engine structure must be suitably protected against deterioration or loss of strength in service due to any cause, including weathering, corrosion and abrasion.

B.VLR.19 Inspection provisions

There must be means to allow the close examination of each part that requires recurring inspection, adjustment for proper alignment and functioning, lubrication or rigging and de-rigging.

B.VLR.21 Engine Control System

The engine control system must operate with the ease, smoothness, and positiveness appropriate to its functions.

B.VLR.23 Engine Mounting System

Each engine component which forms part of the engine mounting and any other parts of the engine liable to be critically affected must, when the engine is properly supported by a suitable engine-mounting structure,

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

(b) Be able to support ultimate loads without failure. This must be shown by-

(1) Applying ultimate loads to the structure in a static test for at least 3 seconds; or

(2) Dynamic tests simulating actual load application.

B.VLR.25 Fire prevention

(a) The design and construction of the engine and the materials used must minimise the probability of the occurrence and spread of fire during normal operation and failure conditions and must minimise the effects of such a fire.

(b) Except as required by subparagraph (c), each external line, fitting and other component which conveys flammable fluid during engine operation must be at least fire resistant, except that flammable fluid tanks and supports which are part of and attached to the engine must be fireproof or be enclosed by a fireproof shield unless damage by fire to any non-fireproof part will not cause leakage or spillage of flammable fluid. Components must be shielded or located so as to safeguard against the ignition of leaking flammable fluid. An integral oil sump of less than 23.7 litre capacity on an engine need not be fireproof nor be enclosed by a fireproof shield.

(c) Subparagraph (b) does not apply to vent and drain lines, and their fittings whose failure will not result in, or add to, a fire hazard.

(d) An engine component designed, constructed and installed as a firewall must be:

(1) Fireproof; and

(2) Constructed so that no hazardous quantity of air, fluid or flame can pass around or through the firewall; and:

(3) Protected against corrosion

(e) In addition to the requirements of subparagraphs (a) and (b), engine control systems components which are located in a designated fire zone must be at least fire resistant.

(f) Any components, modules, equipment and accessories which are susceptible to or are potential sources of static discharges or electrical fault currents must be designed and constructed so as to be grounded to the engine reference in order to minimise the risk of ignition in external areas where flammable fluids or vapours could be present.

(g) Those features of the engine which form part of the mounting structure or engine attachment points must be fireproof, either by construction or by protection, or protected so they can perform their essential functions for at least 5 minutes under any foreseeable powerplant fire conditions.

B.VLR.27 Durability
(See AMC B.VLR.27)

Engine design and construction must minimise the probability of occurrence of an unsafe condition of the engine between overhauls.

B.VLR.29 Engine cooling

Engine design and construction must provide the necessary cooling under conditions in which the rotorcraft is expected to operate.

B.VLR.31 Accessory attachment

Each accessory drive and mounting attachment must be designed and constructed so that the engine will operate properly with the accessories attached. The design of the engine must allow the examination, adjustment or removal of each essential engine accessory.

B.VLR.33 Vibration
(See AMC B.VLR.33)

(a) The engine must be designed and constructed to function from idling to 103% crankshaft rotational speed at maximum take off conditions without vibration levels which may affect the integrity of parts and assemblies.

(b) The engine must withstand a vibration survey throughout the expected operating range of rotational speed and power of the engine and up to an engine speed equivalent to take-off power on rotorcraft rotor speed plus 3%. Each accessory drive and mounting attachment must be loaded with the critical loads expected in service.

B.VLR.35 Ignition
(See AMC B.VLR.35)

Except for compression ignition engines, the engine must be equipped with a dual ignition system having all the magnetic and electrical circuits entirely independent, or with a single ignition system of at least equal reliability to a dual system. The ignition system must function throughout the complete operating range of the engine under all starting and flight conditions.

B.VLR.37 Fuel and induction system

(a) Each fuel specification to be approved, including any additive, and the associated limitations in flow, temperature and pressure that ensure proper engine

functioning under all intended operating conditions must be declared and substantiated. (See AMC B.VLR.37(a))

(b) The fuel system of the engine must be designed and constructed to supply the appropriate mixture of fuel to the combustion chambers throughout the complete operating range of the engine under all starting, flight and atmospheric conditions.

(c) The intake passages of the engine through which air, or fuel in combination with air, passes must be designed and constructed to minimise ice accretion and vapour condensation in those passages. The engine must be designed and constructed to permit the use of a means for ice prevention.

(d) The type and degree of fuel filtering necessary for protection of the engine fuel system against foreign particles in the fuel must be specified. The applicant must show (e.g. within the 50-hour run prescribed in B.VLR.47 (a)) that foreign particles passing through the prescribed filtering means will not critically impair engine fuel system functioning.

(e) Each fuel system for a compression ignition engine must be capable of sustained operation throughout its flow and pressure range with fuel initially saturated with water at 27°C and having 0.198 cm³ of free water per litre added and cooled to the most critical condition for icing likely to be encountered in operation.

(f) Each passage in the induction system that conducts a mixture of fuel and air, and in which fuel may accumulate, must be self-draining to prevent a liquid lock in the combustion chambers. This applies to all attitudes selected by the applicant.

B.VLR.39 Lubrication system

(a) The lubrication system of the engine must be designed and constructed so that it will function properly in all attitudes and atmospheric conditions in which the rotorcraft is expected to operate. In wet-sump engines this requirement must be met when the engine contains only the minimum oil quantity, the minimum quantity being not more than half the maximum quantity.

(b) The lubrication system of the engine must be designed and constructed to allow installing a means of cooling the lubricant.

(c) The crankcase must be vented to preclude leakage of oil from excessive pressure in the crankcase.

(d) If an engine depends upon a fuel/oil mixture for lubrication, then a reliable means of providing it with the appropriate mixture must be established.

(e) If the engine lubrication depends upon oil pre-mixed to fuel in a declared fixed percentage, then the applicant must demonstrate that this percentage can assure appropriate engine lubrication also in reduced fuel consumption conditions throughout the whole range of intended conditions in which the rotorcraft is expected to operate.

B.VLR.41 High Energy Rotors

Equipment with high-energy rotors must be such as to meet one of the following:

(a) Failures will not result in significant non containment of high energy debris, or

(b) An acceptable level of integrity of the design, including the high energy parts, has been established, or

(c) An appropriate combination of subparagraphs (a) and (b).

B.VLR.43 Calibration test
(See AMC B.VLR.43)

Each engine must be subjected to the calibration tests necessary to establish its power characteristics and the conditions for the endurance test specified in B.VLR.47 (a) to (c). The results of the power characteristics calibration tests form the basis for establishing the characteristics of the engine over its entire operating range of crankshaft rotational speeds, manifold pressures and fuel/air mixture settings. Power ratings are based on standard atmospheric conditions at sea level.

B.VLR.45 Detonation test (spark ignition only)

A test must be conducted using the dual ignition system and must be repeated using each separate ignition system alone to determine whether it can function without detonation throughout the range of intended conditions of operation.

B.VLR.47 Endurance test
(See AMC B.VLR.47)

(a) The engine must be subjected to an endurance test that includes a total of 50 hours of operation and consists of the cycles specified in subparagraph (c).

(b) Additional endurance testing at particular rotational speed(s) may be required depending on the results of the tests prescribed in B.VLR.33 to establish

the ability of the engine to operate without fatigue failure.

(c) Each cycle must be conducted as follows:

Sequence	Duration (Minutes)	Operating Conditions
1	5	Starting - Idle
2	5	Take-off power
3	5	Cooling run (Idle)
4	5	Take-off power
5	5	Cooling run (Idle)
6	5	Take-off power
7	5	Cooling run (Idle)
8	15	75% of maximum continuous power
9	5	Cooling run (Idle)
10	60	Maximum continuous power
11	5	Cooling run and stop
Total:	120	

(d) During or following the endurance test the fuel and oil consumption must be determined.

B.VLR.49 Operation test

The operation test must include the demonstration of backfire characteristics, starting-idling, acceleration, running with a single ignition system, over-speeding and any other operational characteristics of the engine.

B.VLR.51 Engine component test

(a) For those systems or components that cannot be adequately substantiated by the endurance testing of B.VLR.47 (a) to (c), additional tests or analysis must be conducted to demonstrate that the systems or components are able to perform the intended functions in all declared environmental and operating conditions.

(b) Temperature limits must be established for each component that requires temperature-controlling provisions to ensure satisfactory functioning, reliability and durability.

B.VLR.53 Tear-down inspection

After completing the endurance test and engine component tests as required-

- (a) Each engine must be completely disassembled;
- (b) Each component having an adjustment setting and a functioning characteristic that can be established independent of installation on the engine must retain each setting and functioning characteristic within the limits that were established and recorded at the beginning of the test; and
- (c) Each engine component must conform to the type design and be eligible for incorporation into an engine for continued operation.

B.VLR.55 Engine adjustment and parts replacement

- (a) The applicant may, in conducting the bench tests, use separate engines of identical design and construction in the vibration, calibration, detonation, endurance, and operation tests, except that, if a separate engine is used for the endurance test it must be subjected to the calibration test requested by B.VLR.43.
- (b) The applicant may service and make minor repairs to the engine during the bench tests accordance with the service and maintenance instructions. If the frequency of the service is excessive, or the number of stops due to engine malfunction is excessive, or a major repair, or replacement of a part is found necessary during the bench tests or as the result of findings from the tear-down inspection, the engine or its parts may be subjected to any additional test the Agency finds necessary.

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Appendix C

Test Procedure For Self-Extinguishing Materials

C.VLR.1 Conditioning

Specimens must be conditioned to $21^{\circ}\text{C} \pm 2.8^{\circ}\text{C}$ ($70^{\circ}\text{F} \pm 5^{\circ}\text{F}$) and at $50\% \pm 5\%$ relative humidity until moisture equilibrium is reached or for 24 hours. Only one specimen at a time may be removed from the conditioning environment immediately before subjecting it to the flame.

C.VLR.2 Specimen configuration

Materials must be tested either as a section cut from a fabricated part as installed in the rotorcraft or as a specimen simulating a cut section, such as a specimen cut from a flat sheet of the material or a model of the fabricated part. The specimen may be cut from any location in fabricated part; however, fabricated units such as a sandwich panel, may not be separated for test. The specimen thickness must be no thicker than the minimum thickness to be qualified for use in the rotorcraft, except that thick foam parts must be tested in 12.7 mm (0.5 inch) thickness. In the case of fabrics, both the warp and fill direction of the weave must be tested to determine the most critical flammability conditions. When performing the test prescribed in paragraph C4 of this Appendix, the specimen must be mounted in a metal frame so that –

(a) The two long edges and the upper edge are held securely;

(b) The exposed area of the specimen is at least 50.8 mm (2 inches) wide and 304.8 mm (12 inches) long, unless the actual size used in the rotorcraft is smaller; and

(c) The edge to which the burner flame is applied must not consist of the finished or protected edge of the specimen but must be representative of the actual cross section of the material or part installed in the rotorcraft.

C.VLR.3 Apparatus

Tests must be conducted in a draughtfree cabinet in accordance with Federal Test Method Standard 191 Method 5903 (revised Method 5902) which is available from the General Services Administration, Business Service Center, Region 3, Seventh and D Streets SW, Washington, D.C. 20407, or with some other approved equivalent method. Specimens which are too large for the cabinet must be tested in similar draught-free conditions.

C.VLR.4 Vertical test

A minimum of three specimens must be tested and the results averaged. For fabrics, the direction of weave corresponding to the most critical flammability conditions must be parallel to the longest dimension. Each specimen must be supported vertically. The specimen must be exposed to a Bunsen or Tirrill burner with a nominal 9.5 mm (0.375 inch) I.D. tube adjusted to give a flame of 38.1 mm (1.5 inches) in height. The minimum flame temperature measured by a calibrated thermocouple pyrometer in the centre of the flame must be 843°C (1550°F). The lower edge of the specimen must be 19 mm (0.75 inch) above the top edge of the burner. The flame must be applied to the centre-line of the lower edge of the specimen. The flame must be applied for 60 seconds and then removed. Flame time, burn length, and flaming time of drippings, if any, must be recorded. The burn length determined in accordance with paragraph C5 of this Appendix must be measured to the nearest 2.5 mm (0.1 inch).

C.VLR.5 Burn length

Burn length is the distance from the original edge to the farthest evidence of damage to the test specimen due to flame impingement, including areas of partial or complete consumption, charring, or embrittlement, but not including areas sooted, stained, warped, or discoloured, nor areas where material has shrunk or melted away from the heat source.

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EASA Certification Specifications
for
Very Light Rotorcraft

CS-VLR
Book 2

Acceptable Means of Compliance

AMC - SUBPART A**GENERAL****AMC VLR General**

The AMC to CS-VLR consists of FAA AC 27-1B dated 30.09.1999 with the changes/additions given in this Book 2 of CS-VLR.

**AMC VLR.1
Applicability**

1. For the purposes of this CS VLR a very light rotorcraft (helicopter) design is assumed to be simple if it incorporates:

- A single main rotor
- A single anti-torque device (typically a conventional tail rotor or fenestron).
- A non-retracting skid or ski landing gear or, a fixed float landing gear.
- Not more than one spark or compression ignition engine. With or without electronic ignition, fuel injection or engine management systems as appropriate. (turbine and/or rocket engines are excluded).
- A simple fuel system. This definition relates to the fuel system components installed on the airframe and excludes those items normally comprising the powerplanted engine assembly e.g. fuel injection systems.

and to exclude :

- Boosted or automated flight controls.
- Combustion heaters.

2. Specific configurations such as turbine and/or rocket engines, hydraulic systems, stability augmentation systems, autopilots, pop-out emergency floatation gear, wheeled undercarriages, retracting undercarriages, "Notar style" devices, external lights, VFR night operations, load and related attaching means will be addressed with a special condition and/or in accordance to applicable CS-27 requirements or equivalent.

3. Similarly this code does not address gyroplanes. Gyroplanes will be addressed by special conditions and / or in accordance with the applicable CS-27 requirements or equivalent.

AMC-SUBPART B

FLIGHT

AMC VLR.143(d)

Controllability and manoeuvrability

Reserved

AMC-SUBPART C
STRENGTH REQUIREMENTS

AMC VLR.307(a)
Proof of Structure

1. Substantiating load tests made in accordance with CS VLR.307(a) should normally be taken to ultimate design load.
2. The results obtained from strength tests should be so corrected for departures from the mechanical properties and dimensions assumed in the design calculations as to establish that the possibility of any structure having a strength less than the design value, owing to material and dimensional variation, is extremely remote.

AMC VLR.547(a)
Main Rotor Structure

A rotor is an assembly of rotating components which includes the rotor hub, blades, blade dampers, the pitch control mechanisms, and all other parts which rotate with the assembly.

AMC VLR.549(b)(1)
Fuselage, landing gear, rotor pylon and engine structures

When the engine is certified under the requirements of appendix B to this CS.VLR then the requirements of CS VLR.361 should be taken into account for the engine structure when demonstrating compliance with CS VLR 549(b)(1).

AMC-SUBPART D
DESIGN AND CONSTRUCTION

AMC VLR.602
Critical Parts

1 Explanation

The objective of identifying critical parts is to ensure that critical parts are controlled during design, manufacture and throughout their service life so that the risk of failure in service is minimised by ensuring that the critical parts maintain the critical characteristics on which certification is based. Many rotorcraft manufacturers already have procedures in place within their companies for handling “critical parts”. These may be required by their dealings with other customers, frequently military (e.g. US DoD, UK MoD, Italian MoD). Although these programmes may have slightly different definitions of “critical parts” and have sometimes been called “flight safety parts”, “critical parts”, “vital parts”, or “identifiable parts”, they have in the past been accepted as meeting the intent of this requirement and providing the expected level of safety.

2 Procedures

The rotorcraft manufacturer should establish a critical parts plan. The policies and procedures which constitute that plan should be such as to ensure that:

a. All critical parts of the rotorcraft are identified by means of a failure assessment and a critical parts list is established. The use of the word “could” in paragraph CS VLR.602(a) of the rule means that this failure assessment should consider the effect of flight regime (i.e. forward flight, hover, etc.). The operational environment need not be considered. With respect to this rule, the term “catastrophic” means the inability to conduct an autorotation to a safe landing, without exceptional piloting skills, assuming a suitable landing surface.

b. Documentation draws the attention of the personnel involved in the design, manufacture, maintenance, inspection, and overhaul of a critical part to the special nature of the part and details the relevant special instructions. For example all drawings, work sheets, inspection documents etc, could be prominently annotated with the words ‘critical part’ or equivalent and the instructions for continued airworthiness and overhaul manuals (if applicable) should clearly identify critical parts and include the needed maintenance and overhaul instructions. The documentation should:

- (1) Contain comprehensive instructions for the maintenance, inspection and overhaul of critical parts and emphasise the importance of these special procedures;
- (2) Indicate to operators and overhaulers that unauthorised repairs or modifications to critical parts may have hazardous consequences;
- (3) Emphasise the need for careful handling and protection against damage or corrosion during maintenance, overhaul, storage, and transportation and the need for accurate recording and control of service life (if applicable).
- (4) Require notification to the manufacturer of any unusual wear or deterioration of critical parts and the return of affected parts for investigation when appropriate;

c. To the extent needed for control of critical characteristics, procedures and processes for manufacturing critical parts (including test articles) are defined (for example material source, forging procedures, machining operations and sequence, inspection techniques, and acceptance

and rejection criteria). Procedures for changing these manufacturing procedures should also be established.

d. Any changes to the manufacturing procedures, to the design of a critical part, to the approved operating environment, or to the design loading spectrum are evaluated to establish the effects, if any, on the fatigue evaluation of the part.

e. Materials review procedures for critical parts (i.e. procedures for determining the disposition of parts having manufacturing errors or material flaws) are in accordance with paragraphs c. and d. above.

f. Critical parts are identified as required, and relevant records relating to the identification are maintained such that it is possible to establish the manufacturing history of the individual parts or batches of parts.

g. The critical characteristics of critical parts produced in whole or in part by suppliers are maintained.

AMC VLR.613(b)

Material Strength Properties and Design Values

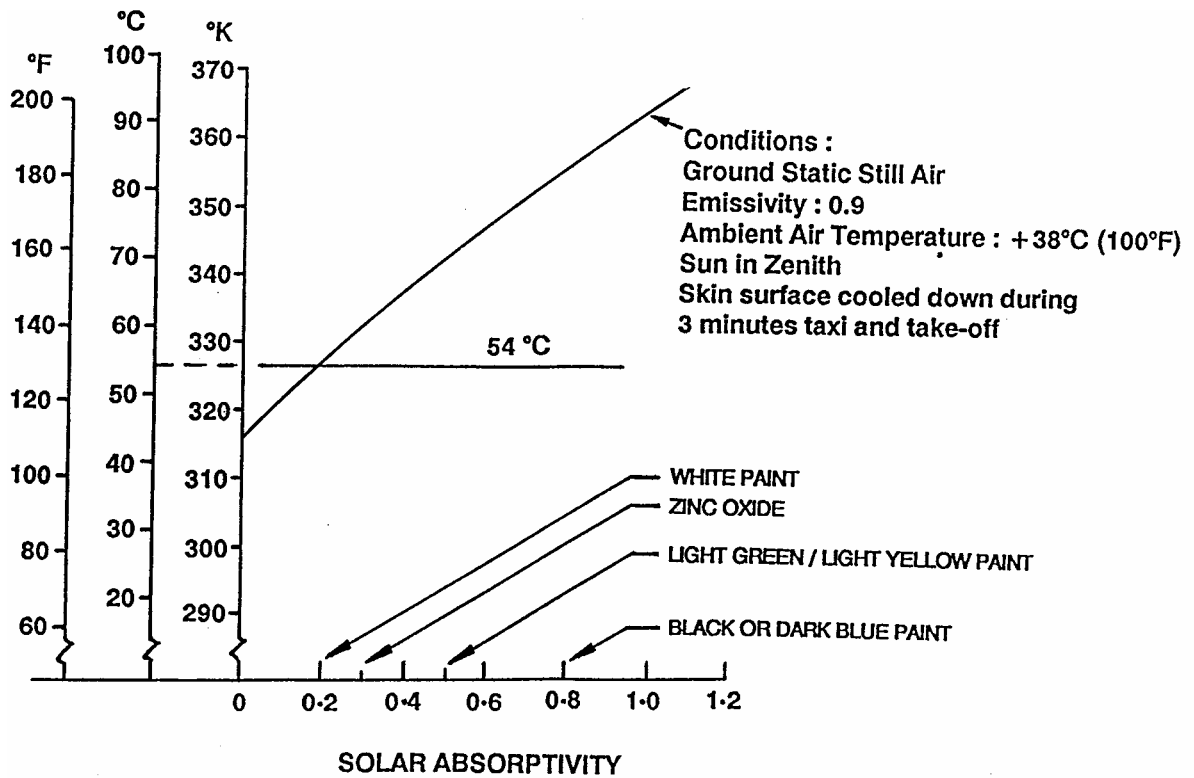
Material specifications should be those contained in documents accepted either specifically by the Agency or by having been prepared by an organisation or person which the Agency accepts has the necessary capabilities. In defining design properties these material specification values should be modified and/or extended as necessary by the constructor to take account of manufacturing practices (for example, method of construction, forming, machining, and subsequent heat treatment).

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AMC VLR.613(c)
Material Strength Properties and Design Values

Test Temperature :

- a. For white painted surface and vertical sunlight: 54°C. If the test cannot be performed at this temperature an additional factor of 1.25 should be used.
- b. For other coloured surfaces the curve below may be used to determine the test temperature.



Curve based on: NASA Conference Publication 2036
 NASA Contractor Report 3290

AMC VLR.615
Design Properties

When the manufacturer is unable to provide satisfactory statistical justification for A and B values, especially in the case of manufacturing of composite materials, a safety super factor should be applied to ensure that A and B values are met.

AMC VLR.685(d)(4)
Control System Details

The inside diameter of the pulley groove should be not less than 300 times the diameter of each elemental strand.

AMC VLR.725 Limit Drop Test

Reference M. Chernoff "Analysis and Design of skid gears for level landing"

Rational analysis for the limit load factor determination, such as that outlined in the reference, might be submitted to the Agency instead of the limit and reserve energy drop tests required in CS VLR.725 and CS VLR.727.

AMC VLR.777 Cockpit controls

A maximum occupant height of 1.83 m. (6 ft.) may be assumed for compliance demonstration.

AMC VLR.785(e) Seats, Safety Belts and Harnesses

Installation of shoulder harness. Figures 1(a), 1(b), and 1(c) show the recommended installation geometry for this type of restraint.

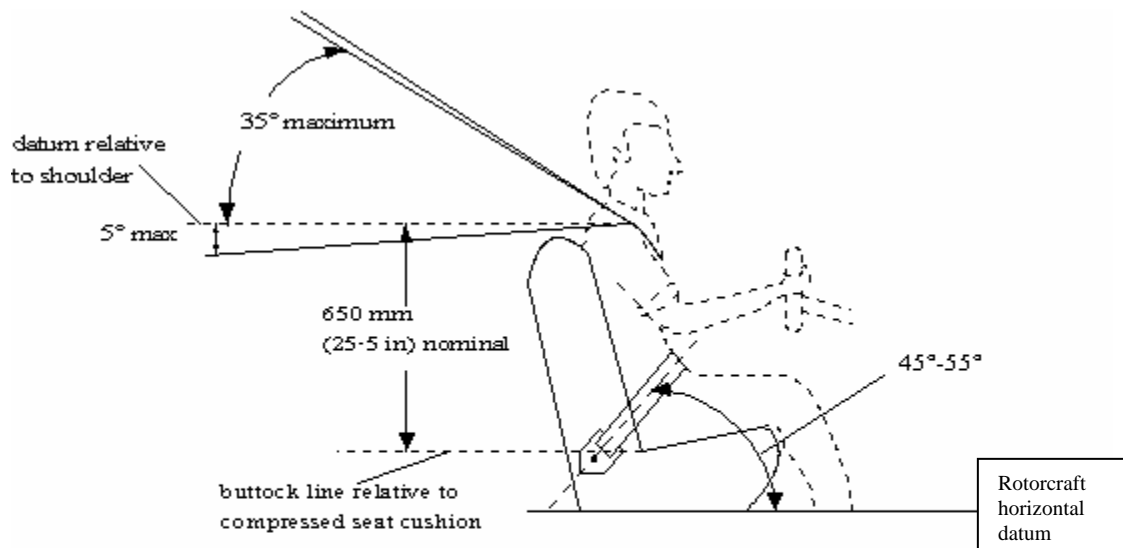


FIGURE 1(a)

Safety belt with one diagonal shoulder strap (ODS safety belt). Figures 2(a) and 2(b) show the recommended installation geometry for this type of restraint.

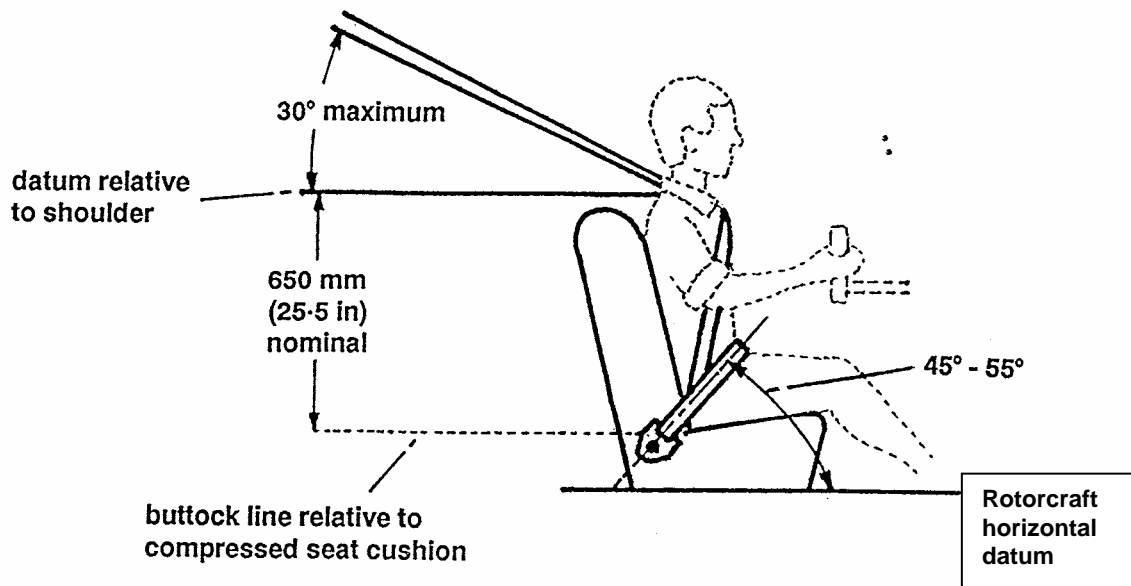


FIGURE 2(a)

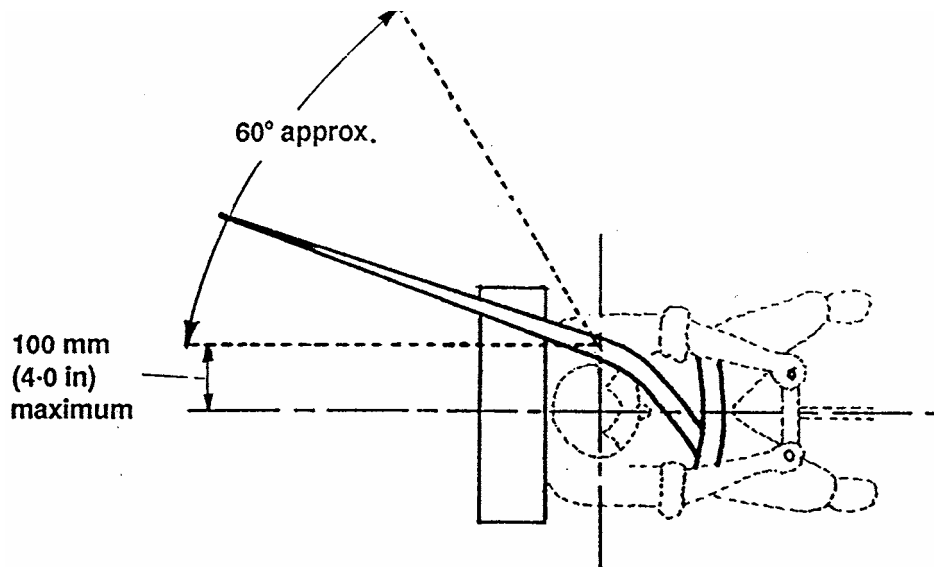


FIGURE 2(b)

NOTES:

1. The total length of the diagonal shoulder strap should be kept as short as possible, in order to reduce the effect of webbing stretch under the emergency alighting loads.
2. Where the seat back is of adequate strength and such height that the harness geometry relative to the shoulder conforms with the Figure 2(a) (i.e. 650 mm (25.5 in)), it is permissible to attach the shoulder strap to the seat back or via guide loops to the rotorcraft floor.
3. The installation should be such as to minimise the risk of injury or chafing of the wearer's neck; a guide loop may assist in achieving this.

AMC-SUBPART E**POWERPLANT****AMC VLR.901(b)
Installation**

A reliability program should be provided in order to demonstrate that the product (engine and powerplant installation) can ensure a safe operation between the proposed normal inspections or overhauls.

The reliability program should be based on the evidence resulting from the endurance test required by B.VLR.33, the vibration evaluation requested by the AMC for B.VLR.21 and the safety assessment and enhanced design review requested by the AMC for B.VLR.15.

Procedures for in service monitoring (such as installation of sensors that provide information on the integrity of the in-service engine/powerplant components) are also recommended in order to support this reliability program.

**AMC VLR.901(c)
Installation**

The instructions for installing the engine referred to in CS VLR.901(c)(1) are those required under CS E 20(d) or B.VLR.3.

**AMC VLR.903 (a)
Engine Type Certification**

Engines certificated under CS-E are accepted as complying with appendix B.

**AMC VLR.907
Vibration**

1. Explanation Section CS VLR.907 is intended to require the design of the rotor drive system, including the engine, to be free from harmful vibration.

The mechanical coupling of the engine to the rotor drive system could lead to a rather complex harmonic response, in terms of torsion vibration, adding resonant frequencies to the engine shaft that otherwise would be absent when the engine is operated on a test bench.

2. Procedure The absence of abnormal wear on main rotating engine components, the free wheel and rotor drive system between the engine and the rotor hubs at the end of the flight test program and flight survey is considered an acceptable means of compliance.

The results of the endurance test may also be utilised. In order to provide evidence of lack of abnormal wear on the free wheel and on the rotating parts of the engine it is necessary to :

- a. Identify the components installed on the rotorcraft to be used for the flight test programme and measure their tolerances.
- b. Report the conditions of components at the end of the flight test program

AMC VLR.1011(c)
Oil System, General

In assessing the reliance that can be placed upon the means for providing the appropriate fuel/oil mixture to the engine to prevent a hazardous condition, account should be taken of, for example -

- a. The tolerance of the engine to fuel/oil mixture ratios other than the optimum;
- b. The procedure established for refuelling and introducing the appropriate amount of oil; and
- c. The means by which the pilot may check that the fuel contains an adequate mixture of oil.

AMC - SUBPART F**AMC VLR.1305(b)****Powerplant Instruments**

Many air-cooled engines used in helicopters were originally designed for use in fixed wing aircraft where they could take advantage of a flow of forced cooling air, and thus be reasonably evenly cooled. However, because of the installation differences between fixed wing aircraft and helicopters it is known that air-cooled engines installed into helicopters can be somewhat difficult to cool evenly. Hence it is possible for one or more cylinders to run hotter than the rest with adverse consequences on engine reliability, if they are allowed to overheat. Therefore the engine cylinder head temperature gauge required by CS VLR.1305 (b) should monitor the most critical (hottest running) cylinder.

AMC VLR.1305(d)**Powerplant Instruments**

A single indicator is acceptable for each group of interconnected tanks functioning as a single tank, such that individual tanks cannot be isolated.

AMC VLR.1305(e)**Powerplant Instruments**

An altitude engine is defined as: "A reciprocating aircraft engine having a rated take-off power that is producible from sea level to an established higher altitude." Sometimes these engines are referred to as "turbo-normalised". Practically the usual means of achieving this situation is by installation to the engine of a super-charger or turbo-super-charger with an automatically controlled waste-gate.

AMC - APPENDIX B**ENGINES****AMC B.VLR.1****Applicability**

1. Engines certificated under CS-E are accepted as complying with appendix B.
2. If the engine is based on a commercially available unit then it may be impossible to have access to all the pertinent design data necessary to show compliance with the requirements of this appendix B. If this is the case then alternative means of compliance that would provide equivalent levels of safety should be proposed.
3. Where the engine is based on a commercially available unit, procedures should be in place showing how:
 - a. In-service airworthiness issues arising because of design and manufacturing changes made to the base engine by the original manufacturer of the engine will be prevented, and
 - b. Any design related in-service airworthiness issues are resolved.

AMC B.VLR.27**Durability**

1. The intent of this requirement is to encourage the performance of a design review of the engine and a safety assessment of its components that would allow the minimisation of the development of an unsafe engine condition between the established inspection intervals and overhaul periods.
2. Design review. It should be demonstrated that the engine and its installation on the rotorcraft do not have any design features or details that experience has shown to be hazardous or unreliable, the suitability of each questionable design detail and part should be shown by tests.
3. Safety Assessment. The safety assessment and related failure analysis should normally include investigation of those engine components that could affect the functioning and integrity of the major rotating assemblies, ignition systems, and for the control system all manual and automatic controls (e.g fuel system governors, overspeed limiters, electronic engine management systems). Possible modes of failure, including malfunctions and damage from external sources should be investigated and inspection/overhaul intervals established such as to minimise the development of unsafe condition for the engine.

The failure of individual components of the engine need not be included in the analysis if it can be demonstrated that the possibility of such failure is sufficiently remote.

AMC B.VLR.33**Vibration**

1. A vibration evaluation of the engine is requested as a preliminary fatigue assessment before the engine is installed on the rotorcraft (see paragraph 2 below). The intent of this requirement is to demonstrate that the engine is free from harmful vibration under all normal operating conditions. The torsional and bending vibration characteristics of the crankshaft and the drive shaft should be determined over the range of crankshaft speed, from idling speed to 103 % of the maximum desired take-off speed rating. And it should be demonstrated that the associated loads and stresses are below the endurance limit of the materials used for the engine construction. This investigation may be accomplished by a combination of analysis and test.

2. The mechanical coupling of the engines to the rotor drive system creates, for torsional vibration considerations, a complicated system that responds to any forced or resonant frequency. Antinodes or nodes and frequencies may exist in the engine shaft which are absent when the engine is operated on a test stand; therefore, the vibration investigation conducted under B.VLR.33(a) is not conclusive with respect to torsional loads. This requirement requires the substantiation of the effects of vibration on any part of the engine when installed on the rotorcraft and when subjected to the expected flight loading conditions. The load survey requested by CS-VLR 571 will provide the loads and the stresses associated to the vibration effects on the engine. The vibration evaluation should include low cycle fatigue associated with ground-air-ground cycles.

AMC B.VLR.35
Ignition

Attention should be paid to minimising the detrimental effects of electromagnetic radiation on electronic ignition systems and related electronic engine management systems. Irrespective of whether the radiation has been generated within the rotorcraft or external to it i.e HIRF. It is expected that demonstrations of compliance with CS VLR.1309(b) and B.VLR.27 will address this issue.

AMC B.VLR.37(a)
Fuel and Induction Systems

Attention should be paid to minimising the detrimental effects of electromagnetic radiation on electronic fuel injection systems and related electronic engine management systems. Irrespective of whether the radiation has been generated within the rotorcraft or external to it i.e HIRF. It is expected that demonstrations of compliance with CS VLR.1309(b) and B.VLR.27 will address this issue.

AMC B.VLR.43
Calibration Test

The calibration test should be carried out before the commencement of the endurance test, (B.VLR.47) and after it has been concluded. Comparison of the before and after test results should provide an indication of engine degradation.

AMC B.VLR.47
Endurance Testing

The intent of this test is to demonstrate a minimum level of operability of the complete engine within its approved ratings, limitations, inspections and maintenance requirements

The engine should be tested in a condition representative of its installation. All required engine driven accessories necessary for its functioning when installed, such as engine driven cooling fans in the case of some air cooled engines, should be fitted to the test engine.