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GOVERNMENT OF INDIA

OFFICE OF DIRECTOR GENERAL OF CIVIL AVIATION

AEAC NO. 01 of 2024

11th September, 2024

F. No. DGCA-31018/5/2024-DRONE-Dte

AIRCRAFT ENGINEERING ADVISORY CIRCULAR

Subject: Guidance Material on Type Certification of vertical take-off and landing capable aircraft (VCA)

1. Introduction

1.1 The rapid evolution of vertical take-off and landing (VTOL) aircraft necessitates the development of specialized airworthiness requirements for the Type Certification of such aircraft to support their unique operational requirements.

1.2 This guidance material aims to provide comprehensive type certification requirement including the essential performance based airworthiness criteria for VCA. In developing the guidance material global practise have been taken into consideration.

1.3 This Advisory Circular is issued under the provisions of CAR-21 issued under Rule 133A of The Aircraft Rules, 1937.

2. Applicability and Scope

2.1 This airworthiness certification requirements applies to

(a) electric Vertical Take-off and landing (VTOL) capable aircraft with pilot onboard

(b) with a maximum take-off weight upto 5700kg

(c) Intended to be used for Advanced Air Mobility (AAM).

2.2 This circular in the present form will not apply to lighter than air aircraft, Helicopter and Gyrocopter.

3. Acronyms and Definitions

3.1 Acronyms

AAM	-	Advanced Air Mobility
AC	-	Advisory Circular
AFM	-	Aircraft Flight Manual
CAR	-	Civil Aviation Requirements

ESF	-	Equivalent Safety Findings
FOD	-	Foreign Object Damage
ICAO	-	International Civil Aviation Organization
MTOW	-	Maximum take-off weight
SC	-	Special Conditions
TC	-	Type Certificate
UAS	-	Unmanned Aircraft System
UIN	-	Unique Identification Number
UTM	-	UAS Traffic Management
VCA	-	VTOL capable aircraft
VFR	-	Visual Flight Rules
VLL	-	Very Low Level
VMC	-	visual meteorological conditions
VTOL	-	vertical take-off and landing

3.2 Definitions

Advanced Air Mobility (AAM) *Concept of air transportation that uses electric or hybrid propulsion, often with vertical takeoff and landing (eVTOL) capabilities, to transport people and cargo between places. AAM aims to be more efficient, sustainable, and equitable than current aviation systems;*

Minor damage *means any damage to the aircraft which does not necessitate any 'major repair' as per Subpart M of CAR 21.*

Serious injury *is an injury sustained by a person in an accident and which:*

(a) requires hospitalization for more than 48 hours, commencing within 48 hours from the date when the injury was received; or
(b) results in a fracture of any bone (except simple fractures of fingers, toes, or nose or;
(c) involves lacerations

Take-off decision point (TDP) *is the point used in determining take-off performance from which, a power-unit failure occurring at this point, either a rejected take-off may be made or a take-off safely continued.*

V_D/M_D *means design diving speed.*

Vertiport. *An aerodrome or a defined area on a structure intended to be used wholly or in part for the arrival, departure and surface movement of VCA/SCA;*

VTOL-capable aircraft (VCA). *A heavier-than-air aircraft, other than aeroplane or helicopter, capable of performing vertical take-off and landing by means of more than two lift/ thrust units that are used to provide lift during take-off and landing.*

4. Type Certification Procedures

4.1 The organisation intending to obtain a type certificate for VTOL capable aircraft (VCA) or motor, and/ or propeller used in VCA should also require a Deign Organisation Approval (DOA) from DGCA and a Production Organisation approval (POA) for series production in line with CAR-21 to ensure their capability to design, produce and provide instructions for continuing airworthiness.

4.2 The type certification, production and continuing airworthiness of the VCA, motor, and/ or propeller shall follow the requirements laid down in CAR-21.

4.3 Application for type certification must be made in accordance with the requirements laid down in the Subpart B of CAR-21.

4.4 The airworthiness criteria for VCA placed at **"Annexure A"** will be the primary initial airworthiness certification basis and additional requirements (SC, ESF, Deviations etc.) if required particular to a project shall be dealt as Certification Review Item (CRI).

4.5 The type certification basis shall be reflected on the TCDS.

4.6 An applicant must comply with these airworthiness criteria specified in Annexure A using a means of compliance, which may include consensus standards, accepted by DGCA. An applicant requesting acceptance of a means of compliance must provide the means of compliance in a form and manner acceptable to DGCA.

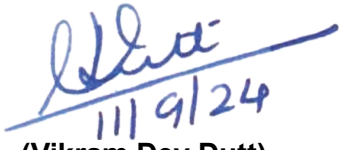
4.7 If the engine/motor and propeller are approved as part of the aircraft type design using the airworthiness criteria of Annexure A, Subparts H and I, these criteria will also be noted on the TCDS. If individual type certificate is obtained for propeller and motor, their type certificate numbers will be listed on the TCDS.

4.8 Any state of design (ICAO contracting state) has type certified VCA under their airworthiness codes shall be validated by DGCA vis-à-vis the proposed airworthiness criteria at "Annexure-A" for its suitability of its operation in India and a validated type certificate will be issued in accordance with CAR Section 6 Series 'A' Part I.

4.9 The noise certification of the VCA - Reserved.

4.10 The airworthiness certification and identification - Reserved.

4.11 The registration of the VCA shall be as per CAR Section 2, Series F, Part I and in case of operation in VLL airspace monitored by UTM, UIN shall also be issued.



(Vikram Dev Dutt)

Director General of Civil Aviation

Annexure-A

Airworthiness Criteria for VTOL Capable Aircraft (VCA)

SUBPART A – GENERAL

VCA.2000 Applicability & Definitions

(a) These airworthiness criteria applies to
  (1) electric Vertical Take-off and landing (VTOL) capable aircraft with pilot onboard
  (2) with a maximum take-off weight upto 5700kg
  (3) Intended to be used for Advanced Air Mobility (AAM).

(b) For the purposes of these airworthiness criteria, the following definitions apply
  (1) ***Continued safe flight and landing*** *–*
    (i). for powered-lift approved for ***"essential performance"*** *means the aircraft is capable of continued controlled flight and landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.*
    (ii). for powered-lift approved for ***"increased performance"*** *means the aircraft is capable of climbing to a safe altitude, on a flight path clear of obstacles, and maintaining level flight to a planned destination or alternate landing, possibly using emergency procedures, without requiring exceptional pilot skill, strength, or alertness.*
  (2) ***Phases of flight*** *means ground operations, takeoff, climb, cruise, descent, approach, hover, and landing.*
  (3) ***Source of lift*** *means one of three sources of lift: thrust-borne, wing-borne, and semi thrust- borne. Thrust-borne is defined as when the weight of the aircraft is principally supported by lift generated by engine/ motor-driven lift devices. Wing-borne is defined as when the weight of the aircraft is principally supported by aerodynamic lift from fixed airfoil surfaces. Semi-thrust-borne is the combination of thrust-borne and wing-borne, where both forms of lift are used to support the weight of the aircraft.*
  (4) ***Controlled emergency landing*** *means the aircraft design retains the capability to allow the pilot to choose the direction and area of touchdown while reasonably protecting occupants from serious injury. Upon landing, minor damage to the aircraft may be acceptable.*
  (5) ***Critical change of thrust*** *means the most adverse effect on performance or handling qualities resulting from failures of the flight control or propulsive system, either singular or in combination, not shown to be extremely improbable.*
  (6) ***Local events*** *are failures of aircraft systems and components, other than the engine/motor and propeller control system, that may affect the installed environment of the engine/motor and propeller control system.*

VCA.2005 General

(a) The applicant shall define the operational context of the aircraft in terms of altitude, range, intended utility, landing take-off requirements etc. This shall also include various operational environment constraints of the aircraft in which it operates.

(b) The applicant shall perform a system safety analysis (SSA) and the result and actions identified by the SSA shall be used to eliminate risk by including safety features in the design and operational procedures.

(c) The applicant shall demonstrate that the size of the aircraft has been derived by considering operational requirements.

(d) The applicant shall define the payload capacity of the aircraft.

SUBPART B – FLIGHT

VCA.2100 Weight and centre of gravity

(a) The applicant must determine limits for weight and centre of gravity that provide for the safe operation of the aircraft.

(b) The applicant's design must comply with each requirement of this Subpart at critical combinations of weight and centre of gravity within the aircraft's range of loading conditions using acceptable tolerances to DGCA.

(c) The condition of the aircraft at the time of determining its empty weight and centre of gravity must be well defined and easily repeatable.

VCA.2105 Performance data

(a) Unless otherwise prescribed, the aircraft must meet the performance requirements of this subpart in still air and standard atmospheric conditions.

(b) Unless otherwise prescribed, the applicant must develop the performance data required for the following conditions:

(1) altitudes from sea level to the maximum altitude for which certification is being sought; and

(2) Temperatures above and below standard day temperature that are within the range of operating limitations, if those temperatures could have a negative effect on performance.

(c) The procedures used for determining takeoff and landing performance must be executable consistently by pilots of average skill in atmospheric conditions expected to be encountered in service.

(d) Performance data determined in accordance with paragraph (b) of this section must account for losses due to atmospheric conditions, cooling needs, installation losses, downwash considerations, and other demands on power sources.

(e) The hovering ceiling, in and out of ground effect, must be determined over the ranges of weight, altitude, and temperature, if applicable.

(f) Continued safe flight and landing must be possible from any point within the approved flight envelope following a critical change of thrust.

(g) The aircraft must be capable of a controlled emergency landing, following a condition when the aircraft can no longer provide the commanded power or thrust required for continued safe flight and landing, by gliding or autorotation, or an equivalent means to mitigate the risk of loss of power or thrust.

VCA.2110 Minimum safe speed

(a) The applicant must determine the aircraft minimum safe speed for each flight condition encountered in normal operations, including applicable sources of lift and phases of flight, to maintain controlled safe flight. The minimum safe speed determination must account for the most adverse conditions for each flight configuration.

VCA.2115 Take-off performance

(a) The applicant must determine takeoff performance accounting for:

(1) All sources of lift for each takeoff flight path for which certification is sought,
(2) Minimum safe speed safety margins,
(3) Minimum control speeds, and
(4) Climb requirements.

(b) For aircraft approved for essential performance, the applicant must determine the takeoff performance to 50 feet above the takeoff surface such that a rejected takeoff resulting in safe stop or landing can be made at any point along the takeoff flight path following a critical change of thrust.

(c) For aircraft approved for increased performance, the applicant must determine the takeoff performance so that–
(1) Following a critical change of thrust prior to reaching the takeoff decision point, a rejected takeoff resulting in a safe stop or landing can be made. The takeoff decision point may be a speed, an altitude, or both; and
(2) Following a critical change of thrust after passing the takeoff decision point, the aircraft can–
(i). Continue the takeoff and climb to 50 feet above the takeoff surface; and
(ii). Subsequently achieve the configuration and airspeed used in compliance with climb requirements as per **VCA.2120**.

VCA.2120 Climb requirements

(a) The applicant must demonstrate minimum climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) The applicant must demonstrate minimum climb performance accounting for any loss of thrust not shown to be extremely improbable.

(c) For aircraft approved for **essential performance**, the climb performance after a critical change of thrust must be determined–
(1) Using applicable sources of lift along the takeoff flight path for which certification is being sought at the speeds and configurations selected by the applicant; and
(2) For the transition from the takeoff to the enroute configuration. The total altitude loss must be determined for the weight, altitude, and ambient temperature where level flight cannot be maintained.

(d) For aircraft approved for **increased performance**, the climb performance after a critical change of thrust must be such that–
(1) In thrust-borne and semi-thrust-borne flight:
(i). The steady rate of climb without ground effect, 200 feet above the takeoff surface, is at least 100 feet per minute,
(ii). The steady rate of climb without ground effect, 1000 feet above the takeoff surface, is at least 150 feet per minute,
(iii). The steady rate of climb (or descent) enroute is determined in feet per minute, at each weight, altitude, and temperature at which the aircraft is expected to operate for which certification is requested.

(2) In wing-borne flight, the steady gradient of climb:
(i). During takeoff at the takeoff surface, is at least 0.5 percent with the aircraft in its takeoff configuration(s),
(ii). During takeoff at 400 feet above the takeoff surface, is at least 2.6 percent with the aircraft in its second segment configuration,
(iii). Enroute at 1,500 feet above the takeoff or landing surface, as appropriate, is at least 1.7 percent with the aircraft in a cruise configuration, and
(iv). During a discontinued approach at 400 feet above the landing surface, is not less than 2.7 percent in an approach configuration.

(e) The applicant must determine the performance accordingly for the appropriate sources of lift for gliding, autorotation, or the equivalent means established under **VCA.2105 (g).**

VCA.2125 Climb information

(a) The applicant must determine climb performance at each weight, altitude, and ambient temperature within the operating limitations using the procedures published in the flight manual.

(b) The applicant must determine climb performance accounting for any critical change of thrust.

VCA.2130 Landing

The applicant must determine the following, for standard temperatures at critical combinations of weight and altitude within the operational limits:

(a) The approach and landing speeds and procedures, which allow a pilot of average skill to land within the published landing distance consistently and without causing damage or injury, and which allow for a safe transition to the balked landing conditions of these airworthiness criteria accounting for:
   (1) All sources of lift for each approach and landing flight path for which certification is sought,
   (2) Any minimum or maximum speed safety margins, and
   (3) Minimum control speeds.

(b) For aircraft approved for **essential performance**, the applicant must determine the landing performance from a height of 50 feet above the landing surface. Additionally, the aircraft must be capable of performing a safe landing at any point along the approach flight path following a critical change of thrust.

(c) For aircraft approved for **increased performance**, the applicant must determine the landing performance from a height of 50 feet above the landing surface so that, following a critical change of thrust that occurs prior to the landing decision point, the aircraft can-
   (1) Land and stop safely on the landing surface; or
   (2) Transition to the balked landing condition and performance established in climb requirements as per **VCA.2120.**

FLIGHT CHARACTERISTICS

VCA.2135 Controllability

(a) The aircraft must be controllable and maneuverable, without requiring exceptional piloting skill, alertness, or strength, within the operating envelope—
   (1) At all loading conditions for which certification is requested;
   (2) During all phases of flight while using applicable sources of lift;
   (3) With likely flight control or propulsion system failure;
   (4) During configuration changes;
   (5) In all degraded flight control system operating modes not shown to be extremely improbable;
   (6) In thrust-borne operation, and must be controllable in wind velocities declared and demonstrated from any azimuth angle by the OEM; and
   (7) The aircraft must be able to safely complete a landing using the steepest approach gradient procedures.
   (8) With reversible flight control if likely to occur
   (9) Considering all effects of sensors, and computational errors and delay.

(b) The applicant must determine critical control parameters, such as limited control, power margins,

and if applicable, account for those parameters in appropriate operating limitations.

(c) It must be possible to make a smooth transition from one flight condition to another (changes in configuration and in source of lift and phase of flight) without exceeding the approved flight envelope.

VCA.2140 Trim

(a) The aircraft must maintain lateral and directional trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under all normal operations while using applicable sources of lift.

(b) The aircraft must maintain longitudinal trim without further force upon, or movement of, the primary flight controls or corresponding trim controls by the pilot, or the flight control system, under the following conditions:
   (1) Climb.
   (2) Level flight.
   (3) Descent.
   (4) Approach.

(c) Residual control forces must not fatigue or distract the pilot during normal operations of the aircraft and likely abnormal or emergency operations, including a critical change of thrust.

VCA.2145 Stability.

(a) The aircraft must exhibit static stability characteristics inclusive of likely failures.

(b) The aircraft must exhibit suitable both the long and short period dynamic stability inclusive of likely failures.

(c) For wing borne and semi-thrust-borne operations:
   (1) No aircraft may exhibit any divergent longitudinal dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants, and
   (2) The aircraft must exhibit lateral-directional dynamic stability inclusive of likely failures.

(d) For thrust borne operations, no aircraft may exhibit any divergent dynamic stability characteristics so unstable as to increase the pilot's workload or otherwise endanger the aircraft and its occupants.

VCA.2150 Minimum safe speed characteristics and warning.

(a) When part of the lift is generated from a fixed wing, the aircraft must have controllable stall characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive stall warning that provides sufficient margin to prevent in advertent stalling and not have a tendency to inadvertently depart controlled safe flight.

(b) For other sources of lift, the aircraft must have controllable characteristics in straight flight, turning flight, and accelerated turning flight with a clear and distinctive warning that provides sufficient margin to prevent inadvertent departures from controlled safe flight.

(c) For all sources of lift, the aircraft must not have the tendency to inadvertently depart controlled safe flight after a sudden change of thrust.

VCA.2155 Ground and water handling characteristics.

For airplanes intended for operation on land or water, the airplane must have controllable longitudinal and directional handling characteristics during taxi, takeoff, and landing operations.

VCA.2160 Vibration, buffeting, and high-speed characteristics

(a) Each part of the aircraft must be free from excessive vibration and buffeting under each appropriate speed and power condition. Vibration and buffeting, for operations up to V_D/M_D, must not interfere with the control of the aircraft or cause excessive fatigue to the flight crew. Stall warning buffet within these limits is allowable.

(b) For inadvertent excursions beyond the maximum approved speed, the aircraft must be able to safely recover back to its approved flight envelope without requiring exceptional piloting skill, strength, or alertness. This recovery may not result in structural damage or loss of control.

VCA.2165 Performance and flight characteristics requirements for flight in atmospheric icing conditions.

(a) An applicant who requests certification for flight in atmospheric icing conditions must show the following in the icing conditions for which certification is requested:

(1) Compliance with each requirement of this subpart, except those applicable to spins and any that must be demonstrated at speeds in excess of—
(i). 250 knots calibrated airspeed (CAS);
(ii). VMO/MMO or VNE; or
(iii). A speed at which the applicant demonstrates the airframe will be free of ice accretion.

(b) The applicant must provide a means to detect icing conditions for which certification is not requested and show the aircraft's ability to avoid or exit those icing conditions.

(c) The applicant must develop an operating limitation to prohibit intentional flight, including takeoff and landing, into icing conditions for which the aircraft is not certified to operate.

SUBPART C – STRUCTURE

VCA.2200 Structural design envelope

The applicant must determine the structural design envelope, which describes the range and limits of aircraft design and operational parameters for which the applicant will show compliance with the requirements of this subpart. The applicant must account for all aircraft design and operational parameters that affect structural loads, strength, durability, and aeroelasticity, including:

(a) Structural design airspeeds, landing descent speeds, and any other airspeed limitation at which the applicant must show compliance to the requirements of this subpart. The structural design airspeeds must—

(1) Be sufficiently greater than the minimum safe speed of the aircraft to safeguard against loss of control in turbulent air; and

(2) Provide sufficient margin for the establishment of practical operational limiting airspeeds.

(b) Design maneuvering load factors not less than those, which may occur within the structural design envelope.

(c) Inertial properties including weight, center of gravity, and mass moments of inertia, accounting

for—

(1) Each critical weight from the aircraft empty weight to the maximum weight; and

(2) The weight and distribution of occupants, payload, and energy-storage systems.

(d) Characteristics of aircraft control systems, including range of motion and tolerances for control surfaces, high lift devices, or other moveable surfaces.

(e) Each critical altitude up to the maximum altitude.

(f) Engine/motor-driven lifting-device rotational speed and ranges, and the maximum rearward and sideward flight speeds.

(g) Thrust-borne, wing-borne, and semi-thrust-borne flight configurations, with associated flight load envelopes.

VCA.2205 Interaction of systems and structures

For airplanes equipped with systems that modify structural performance, alleviate the impact of this subpart's requirements, or provide a means of compliance with this subpart, the applicant must account for the influence and failure of these systems when showing compliance with the requirements of this subpart.

STRUCTURAL LOADS

VCA.2210 Structural design loads

(a) The applicant must:

(1) Determine the applicable structural design loads resulting from likely externally or internally applied pressures, forces, or moments that may occur in flight, ground and water operations, ground and water handling, and while the airplane is parked or moored.

(2) Determine the loads required by paragraph (a) (1) of this section at all critical combinations of parameters, on and within the boundaries of the structural design envelope.

(b) The magnitude and distribution of the applicable structural design loads required by this section must be based on physical principles.

VCA.2215 Flight load conditions

(a) The applicant must determine the structural design loads resulting from the following flight conditions:

(1) Atmospheric gusts where the magnitude and gradient of these gusts are based on measured gust statistics.
(2) Symmetric and asymmetric maneuvers.
(3) Asymmetric thrust resulting from the failure of a powerplant unit.

(b) There must be no vibration or buffeting severe enough to result in structural damage, at any speed up to dive speed, within the structural design envelope, in any configuration and power setting.

VCA.2220 Ground and water load conditions

The applicant must determine the structural design loads resulting from taxi, takeoff, landing, and handling conditions on the applicable surface in normal and adverse attitudes and configurations.

VCA.2225 Component loading conditions

The applicant must determine the structural design loads acting on:

(a) Each engine/motor mount and its supporting structure such that both are designed to withstand loads resulting from—

(1) Powerplant operation combined with flight gust and maneuver loads; and
(2) For non-reciprocating powerplant, sudden powerplant stoppage**.**

(b) Each flight control and high-lift surface, their associated system and supporting structure resulting from—

(1) The inertia of each surface and mass balance attachment;
(2) Flight gusts and maneuvers;
(3) Pilot or automated system inputs;
(4) System induced conditions, including jamming and friction; and
(5) Taxi, takeoff, and landing operations on the applicable surface, including downwind taxi and gusts occurring on the applicable surface.

(c) Reserved.

(d) Engine/motor-driven lifting-device assemblies, considering loads resulting from flight and ground conditions, as well limit input torque at any lifting-device rotational speed.

VCA.2230 Limit and ultimate loads

The applicant must determine—

(a) The limit loads, which are equal to the structural design loads unless otherwise specified elsewhere in these requirements; and;

(b) The ultimate loads, which are equal to the limit loads multiplied by a 1.5 factor of safety unless otherwise specified elsewhere in these requirements.

STRUCTURAL PERFORMANCE

VCA.2235 Structural strength

The structure must support:

(a) Limit loads without—

(1) Interference with the safe operation of the aircraft; and
(2) Detrimental permanent deformation.

(b) Ultimate loads.

VCA.2240 Structural Durability

(a) The applicant must develop and implement inspections or other procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal

injuries, or extended periods of operation with reduced safety margins. Each of the inspections or other procedures developed under this section must be included in the Airworthiness Limitations Section of the Instructions for Continued Airworthiness.

(b) If safety-by-design (fail-safe) is used to comply with paragraph (a) of this section, safety-by-inspection (damage tolerance) must also be incorporated to reliably detect structural damage before the damage could result in structural failure.

(c) Reserved.

(d) The aircraft must be designed to minimize hazards to the aircraft due to structural damage caused by high-energy fragments from an uncontained engine/motor or rotating machinery failure.

VCA.2241 Aeromechanical stability.

The aircraft must be free from dangerous oscillations and aeromechanical instabilities for all configurations and conditions of operation on the ground and in flight**.**

VCA.2245 Aeroelasticity

(a) The aircraft must be free from flutter, control reversal, and divergence—

(1) At all speeds within and sufficiently beyond the structural design envelope;
(2) For any configuration and condition of operation;
(3) Accounting for critical structural modes, and
(4) Accounting for any critical failures or malfunctions.

(b) The applicant must establish tolerances for all quantities that affect aeroelastic stability.

(c) Each component and rotating aerodynamic surface of the aircraft must be free from any aeroelastic instability under each appropriate speed and power condition.

DESIGN

VCA.2250 Design and construction principles

(a) The applicant must design each part, article, and assembly for the expected operating conditions of the aircraft.

(b) Design data must adequately define the part, article, or assembly configuration, its design features, and any materials and processes used.

(c) The applicant must determine the suitability of each design detail and part having an important bearing on safety in operations. The applicant must prevent single failures from resulting in a catastrophic effect upon the aircraft.

(d) The control system must be free from jamming, excessive friction, and excessive deflection when the aircraft is subjected to expected limit air loads.

(e) Doors, canopies, and exits must be protected against inadvertent opening in flight, unless shown to create no hazard when opened in flight.

(f) Reserved.

VCA.2255 Protection of structure

(a) The applicant must protect each part of the airplane, including small parts such as fasteners, against deterioration or loss of strength due to any cause likely to occur in the expected operational environment.

(b) Each part of the airplane must have adequate provisions for ventilation and drainage.

(c) For each part that requires maintenance, preventive maintenance, or servicing, the applicant must incorporate a means into the aircraft design to allow such actions to be accomplished.

VCA.2260 Materials and processes

(a) The applicant must determine the suitability and durability of materials used for parts, articles, and assemblies, accounting for the effects of likely environmental conditions expected in service, the failure of which could prevent continued safe flight and landing.

(b) The methods and processes of fabrication and assembly used must produce consistently sound structures. If a fabrication process requires close control to reach this objective, the applicant must perform the process under an approved process specification.

(c) Except as provided in paragraphs (f) and (g) of this section, the applicant must select design values that ensure material strength with probabilities that account for the criticality of the structural element. Design values must account for the probability of structural failure due to material variability.

(d) If material strength properties are required, a determination of those properties must be based on sufficient tests of material meeting specifications to establish design values on a statistical basis.

(e) If thermal effects are significant on a critical component or structure under normal operating conditions, the applicant must determine those effects on allowable stresses used for design.

(f) Design values, greater than the minimums specified by this section, may be used, where only guaranteed minimum values are normally allowed, if 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 the design.

(g) An applicant may use other material design values if approved by the DGCA.

VCA.2265 Special factors of safety

(a) The applicant must determine a special factor of safety for each critical design value for each part, article, or assembly for which that critical design value is uncertain, and for each part, article, or assembly that is—

(1) Likely to deteriorate in service before normal replacement; or
(2) Subject to appreciable variability because of uncertainties in manufacturing processes or inspection methods.

(b) The applicant must determine a special factor of safety using quality controls and specifications that account for each—

(1) Type of application;
(2) Inspection method;
(3) Structural test requirement;
(4) Sampling percentage; and
(5) Process and material control.

(c) The applicant must multiply the highest pertinent special factor of safety in the design for each part of the structure by each limit and ultimate load, or ultimate load only, if there is no corresponding limit load, such as occurs with emergency condition loading.

STRUCTURAL OCCUPANT PROTECTION

VCA.2270 Emergency conditions

(a) The aircraft, even when damaged in an emergency landing, must protect each occupant against injury that would preclude egress when—

(1) Properly using safety equipment and features provided for in the design;
(2) The occupant experiences ultimate static inertia loads likely to occur in an emergency landing; and
(3) Items of mass, including engines/motor or propeller, within or aft of the cabin, that could injure an occupant, experience ultimate static inertia loads likely to occur in an emergency landing.

(b) The emergency landing conditions specified in paragraph (a)(1) and (a)(2) of this section, must—

(1) Include dynamic conditions that are likely to occur in an emergency landing; and
(2) Not generate loads experienced by the occupants, which exceed established human injury criteria for human tolerance due to restraint or contact with objects in the aircraft.

(c) The aircraft must provide protection for all occupants, accounting for likely flight, ground, and emergency landing conditions.

(d) Each occupant protection system must perform its intended function and not create a hazard that could cause a secondary injury to an occupant. The occupant protection system must not prevent occupant egress or interfere with the operation of the aircraft when not in use.

(e) Each baggage and cargo compartment must—

(1) Be designed for its maximum weight of contents and for the critical load distributions at the maximum load factors corresponding to the flight and ground load conditions determined under these airworthiness criteria;
(2) Have a means to prevent the contents of the compartment from becoming a hazard by impacting occupants or shifting; and
(3) Protect any controls, wiring, lines, equipment, or accessories whose damage or failure would affect safe operations.

SUBPART D – DESIGN AND CONSTRUCTION

VCA.2300 Flight Control Systems

(a) The applicant must design flight control systems to:

(1) Operate easily, smoothly, and positively enough to allow proper performance of their functions;
(2) Protect against likely hazards; and
(3) Ensure that the flightcrew is made suitably aware whenever the means of primary flight control approaches the limits of control authority.

(b) The applicant must design trim systems or trim functions, if installed, to:

(1) Protect against inadvertent, incorrect, or abrupt trim operation; and
(2) Provide information that is required for safe operation.

(c) Features that protect the aircraft against loss of control, or exceeding critical limits, must be designed such that there are no adverse flight characteristics in aircraft response to flight-control inputs, unsteady atmospheric conditions, and other likely conditions, including simultaneous limiting events.

VCA.2305 Landing Gear System

(a) The landing gear must be designed to:

(1) provide stable support and control to the aircraft during surface operation; and
(2) account for likely system failures and likely operation environment (including anticipated limitation exceedances and emergency procedures).

(b) The aircraft must have a reliable means of stopping the aircraft with sufficient kinetic energy absorption to account for landing, in all approved conditions, and of holding the aircraft in position when parked. Aircraft that are required to demonstrate aborted takeoff capability must account for this additional kinetic energy.

(c) For aircraft that have a system that actuates the landing gear, there must be:

(1) a positive means to keep the landing gear in the landing position; and
(2) an alternative means available to bring the landing gear in the landing position when a non-deployed system position would be a hazard.

VCA.2310 Flotation

(a) If certification for intended operations on water is requested, the aircraft must—

(1) Provide buoyancy of 80% in excess of the buoyancy required to support the maximum weight of the aircraft in fresh water; and
(2) Have sufficient margin so that the aircraft will stay afloat at rest in calm water without capsizing in case of a likely float or hull flooding.

(c) If certification for emergency flotation is requested, the aircraft must:

(1) Be equipped with an approved emergency flotation system;
(2) Have flotation units of the emergency flotation system and their attachments to the aircraft capable of withstanding the applicable water loads; and
(3) Be shown to maintain its intended floating attitude in the sea conditions selected by the applicant.

(d) If certification with ditching provisions is requested, the aircraft must:

(1) Be equipped with an approved emergency flotation system that does not rely on manual activation;
(2) Withstand the applicable water loads; and
(3) Be shown to have a safe water entry and to maintain its intended floating attitude in the sea conditions selected by the applicant.

VCA.2311 Bird Strike

The aircraft must be capable of continued safe flight and landing after impact with a 1.0 kg bird.

OCCUPANT SYSTEM DESIGN PROTECTION

VCA 2315 Means of egress and emergency exits

(a) With the cabin configured for take-off or landing, the aircraft is designed to:

(1) Facilitate rapid and safe evacuation of the aircraft in conditions likely to occur following an emergency landing, including on water if an emergency flotation system is included.
(2) Have means of egress (openings, exits or emergency exits), that can be readily located and opened from the inside and outside. The means of opening must be simple and obvious and marked inside and outside the aircraft. If an emergency flotation system is included, the means of egress must be above the water in the intended floating attitude. Additionally, if certification for ditching is requested, the means of egress must be usable in all stable floating attitudes.
(3) Have easy access to emergency exits when present.

VCA.2320 Occupant physical environment

(a) The aircraft must be designed to:

(1) Allow clear communication between the flight crew and passengers;
(2) Protect the occupants against serious injury due to hazards originating from high energy, associated with systems and equipment, including while embarking and disembarking; and
(3) protect the occupants against serious injury due to breakage of windshields, windows, and canopies.

(b) The aircraft must provide each occupant with air at a breathable pressure, free of hazardous concentrations of gases, vapors, and smoke during normal operations and likely failures.

(c) Reserved

(d) If an oxygen system is installed in the aircraft, it must:

(1) Effectively provide oxygen to each user to prevent the effects of hypoxia; and
(2) be free from hazards in itself, in its method of operation, and its effect upon other components.

FIRE AND HIGH ENERGY PROTECTION

VCA.2325 Fire protection

(a) The following materials must be self-extinguishing—

(1) Insulation on electrical wire and electrical cable;

(2) Materials in the baggage and cargo compartments inaccessible in flight;

(b) The following materials must be flame-resistant:

(1) Materials in each compartment accessible in flight; and
(2) Any equipment associated with any electrical cable installation and that would overheat in the event of circuit overload or fault.

(c) Thermal/acoustic materials in the fuselage, if installed, must not be a flame propagation hazard.

(d) Sources of heat within each baggage and cargo compartment that are capable of igniting adjacent objects must be shielded and insulated to prevent such ignition.

(e) Each baggage and cargo compartment must –

(1) Be located where a fire would be visible to the pilots and be accessible for the manual extinguishing of a fire, or
(2) Be equipped with a smoke or fire detection system that warns the pilot, or
(3) Be constructed of, or lined with, fire resistant materials.

(f) There must be a means to extinguish any fire in the cabin such that:

(1) The pilot, while seated, can easily access the fire extinguishing means

(g) Each area where flammable fluids or vapours might escape by leakage of a fluid system must:

(1) Be defined; and
(2) Have a means to minimize the probability of fluid and vapour ignition, and the resultant hazard, if ignition occurs.

VCA.2330 Fire Protection in Fire Zones and Adjacent Areas

(a) A smoke detection system shall be installed onboard to provide an alert to the pilot for taking action for avoiding any damage and land the aircraft in a safe zone.

(b) A fire detection system (wherever fire/overheating condition may be anticipated) and extinguishing system shall be installed on-board to provide an alert to the pilot for taking action for avoiding any damage and land the aircraft in a safe zone.

VCA.2335 Lightning and Static Electricity Protection

(a) The aircraft must be protected against catastrophic effects from lightning.

(b) The aircraft must be protected against hazardous effects caused by an accumulation of electrostatic charge.

VCA.2340 Design and construction information

The following design and construction information must be established:

(a) Operating limitations, procedures and instructions necessary for the safe operation of the aircraft;

(b) the need for instrument markings or placards;

(c) Any additional information necessary for the safe operation of the aircraft; and

(d) Inspections or maintenance to assure continued safe operation.

SUBPART E- POWERPLANT

VCA.2400 Powerplant installation

(a) For the purpose of this subpart, the aircraft powerplant installation must include each component necessary for propulsion, which affects propulsion safety.

(b) Each aircraft engine/motor/propeller must have a type certificate or be approved under the

aircraft type certificate using Subpart H and Subpart I.

(c) The applicant must construct and arrange each powerplant installation to account for:

(1) Likely operating conditions, including foreign object damage;

(2) Sufficient clearance of moving parts to other aircraft parts and their surroundings;

(3) Likely hazards in operation including hazards to ground personnel; and

(4) Vibration and fatigue.

(d) Hazardous accumulations of fluids, vapours, or gases must be isolated from the aircraft and personnel compartments, and be safely contained or discharged.

(e) Powerplant components must comply with their component limitations and installation instructions or be shown not to create a hazard.

VCA.2405 Power or thrust control systems

(a) Any power or thrust control system, or powerplant control system, must be designed so no unsafe condition results during normal operation of the system.

(b) Any single failure or likely combination of failures or malfunctions of a power or thrust control system, or powerplant control system, must not prevent continued safe flight and landing of the aircraft.

(c) Inadvertent flight crew operation of a power or thrust control system, or powerplant control system, must be prevented, or if not prevented, must not prevent continued safe flight and landing of the aircraft.

(d) Unless the failure of an automatic power or thrust control system is extremely remote, the system must
(1) Provide a means for the flight crew to verify the system is in an operating condition;
(2) Provide a means for the flight crew to override the automatic function; and
(3) Prevent inadvertent deactivation of the system.

VCA.2410 Powerplant installation hazard assessment

The applicant must assess each powerplant separately and in relation to other aircraft systems and installations to show that any hazard resulting from the likely failure of any powerplant system, component, or accessory will not:

(a) Prevent continued safe flight and landing or, if continued safe flight and landing cannot be ensured, the hazard has been minimized;

(b) Cause serious injury that may be avoided; and

(c) Require immediate action by any crew member for continued operation of any remaining powerplant system.

VCA.2415 Powerplant ice protection

(a) For aircraft anticipated to enter heavy rain, snow, ice conditions during the flight :

(1) The airplane design, including the induction and inlet system, must prevent foreseeable accumulation of ice or snow that adversely affects powerplant operation.
(2) The powerplant installation design must prevent any accumulation of ice or snow that adversely affects powerplant operation, in those icing conditions for which certification is requested

(b) For aircraft not intended to enter heavy rain, snow, ice conditions intentionally during the flight:

(1) Define appropriate operating limitations to prevent any inadvertent entry into rain, snow, ice conditions during the flight.

VCA.2425 Powerplant operational characteristics

(a) Each installed powerplant must operate without any hazardous characteristics during normal and emergency operation within the range of operating limitations for the aircraft and the engine/motor.

(b) The design must provide for the shutdown and restart of the powerplant in flight within an established operational envelope.

VCA.2430 Energy storage and distribution systems

(a) Each energy system must:

(1) Be designed and arranged to provide independence between multiple energy storage and supply systems so that a failure, including fire, of any one component in one system will not result in the loss of energy storage or supply of another system;
(2) Be designed to prevent catastrophic events due to lightning strikes taking into account direct and indirect effects for aircraft unless it is shown that exposure to lightning is unlikely;
(3) Provide energy to the power plant system installation with adequate margins to ensure safe functioning under all permitted and likely operating conditions, and accounting for likely component failures;
(4) Provide the relevant information established in **VCA.2445** to the flight crew and provide uninterrupted supply of that energy when the system is correctly operated, accounting for likely energy fluctuations;
(5) provide a means to safely remove or isolate the energy stored within the system from the aircraft;
(6) Be designed to retain the energy under all likely operating conditions and minimise hazards to the occupants and people on the ground during any survivable emergency impact (Crash landing).;
(7) Prevent hazardous contamination of the energy supplied to each power plant installation.

(b) Each energy storage system must:

(1) withstand the loads under likely operating conditions without failure;
(2) be isolated from personnel compartments and protected from likely hazards;
(3) be designed to prevent significant loss of stored energy due to energy transfer or venting under likely operating conditions;
(4) provide energy for a sufficient reserve based on a normal flight; and
(5) be capable of jettisoning energy safely if this functionality is provided.

(c) Each energy-storage-refilling or -recharging system must be designed to:

(1) prevent improper refilling or recharging;
(2) prevent the occurrence of any hazard to the aircraft or to persons during refilling or recharging
(3) prevent contamination of the stored energy during likely operating conditions;

(d) Likely errors during ground handling of the aircraft must not lead to a hazardous loss of stored energy.

VCA.2435 Powerplant induction and exhaust systems

(a) Reserved.

(b) Reserved.

VCA.2440 Powerplant installation fire protection

There must be means to isolate and mitigate hazards to the aircraft in the event of a powerplant system fire or overheat in operation.

VCA.2445 Powerplant system installation information

The following Powerplant installation information must be established:

(a) Operating limitations, procedures and instructions necessary for the safe operation of the aircraft;

(b) Propulsion system startup and shutdown procedure shall be clearly documented and supplied to the Flight crew.

(c) Emergency recovery procedure for propulsion system shall be clearly documented and supplied to the Flight crew.

(d) the need for instrument markings or placards;

(e) any additional information necessary for the safe operation of the aircraft;

(f) inspections or maintenance to assure continued safe operation;

(g) information related to the lift/thrust configuration;

(h) techniques and associated limitations for lift/thrust unit starting and stopping; and

(i) Energy level information to support energy management, including consideration of a likely component failure within the system.

SUBPART F – EQUIPMENT

VCA.2500 General requirements on systems and equipment function

This section applies generally to installed equipment and systems unless a section of these airworthiness criteria imposes requirements for a specific piece of equipment, system, or systems and should not supersede any specific requirement of this VCA.

(a) The equipment and systems required for an aircraft to operate safely in the kinds of operations for which certification is requested must be designed and installed to:

(1) Meet the level of safety applicable to the certification and performance level of the aircraft; and
(2) perform their intended function throughout the operating and environmental limits for which the aircraft is certificated.

(b) The systems and equipment not covered by paragraph (a) above, considered separately and in relation to other systems, must be designed and installed so their operation does not have an adverse effect on the aircraft or its occupants.

VCA.2505 Function and installation.

When installed, each item of equipment must function as intended.

VCA.2510 Equipment, systems, and installations

(a) For any aircraft system or equipment whose failure or abnormal operation has not been specifically addressed by another requirement in these airworthiness criteria, the applicant must design and install each system and equipment, such that there is a logical and acceptable inverse relationship between the average probability and the severity of failure conditions to the extent that:

(1) each catastrophic failure condition is extremely improbable and does not result from a single failure;
(2) each hazardous failure condition is extremely remote; and
(3) each major failure condition is remote.

(b) For aircraft approved for increased performance, provisions for in-service monitoring of equipment and systems which failure may have hazardous or catastrophic consequences must be established.

(c) The aircraft systems and network shall be protected from unauthorized access.

VCA.2515 Electrical and electronic system lightning protection

Unless it is shown that exposure to lightning is unlikely:

(a) each electrical or electronic system that performs a function, the failure of which would prevent continued safe flight and landing for a passenger carrying aircraft, or a controlled emergency landing for non-passenger carrying aircraft, must be designed and installed such that:

(1) the function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to lightning; and
(2) the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to lightning.

VCA.2520 High-intensity radiated fields (HIRF) protection

(a) Each electrical and electronic system that perform a function, the failure of which would prevent continued safe flight and landing, must be designed and installed such that:

(1) the function at the aircraft level is not adversely affected during and after the time the aircraft is exposed to the HIRF environment; and
(2) the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment, unless the system's recovery conflicts with other operational or functional requirements of the system.

(b) Each electrical and electronic system that performs a function, the failure of which would reduce the capability of the aircraft or the ability of the flight crew to respond to an adverse operating condition, must be designed and installed such that the system recovers normal operation of that function in a timely manner after the aircraft is exposed to the HIRF environment.

VCA.2525 System power generation, energy storage, and distribution

The power generation, storage, and distribution for any system must be designed and installed to—

(a) Supply the power required for operation of connected loads during all intended operating conditions;

(b) Ensure no single failure or malfunction of any one power supply, distribution system, or other utilization system will prevent the system from supplying the essential loads required for continued safe flight and landing; and

(c) Have enough capacity, if the primary source fails, to supply essential loads, including non-continuous essential loads for the time needed to complete the function required for continued safe flight and landing.

VCA.2530 External and cockpit lighting

(a) The applicant must design and install all lights to minimize any adverse effects on the performance of flight crew duties.

(b) Any position and anti-collision lights, if required by operating rules, must have the intensities, flash rate, colors, fields of coverage, and other characteristics to provide sufficient time for another aircraft to avoid a collision.

(c) Any position lights, if required by operating rules, must include a red light on the left side of the aircraft, a green light on the right side of the aircraft, spaced laterally as far apart as practicable, and a white light facing aft, located on an aft portion of the aircraft or on the wing tips.

(d) Any taxi and landing lights must be designed and installed so they provide sufficient light for night operations.

(e) If certification for intended operations on water is requested, riding lights must provide a white light visible in clear atmospheric conditions.

VCA.2535 Safety equipment

Safety and survival equipment, required by the operating rules, must be reliable, readily accessible, easilyidentifiable, and clearly marked to identify its method of operation.

VCA.2540 Flight in Icing Conditions

An applicant who requests certification for flight in icing conditions must show the following in the icing conditions for which certification is requested:

(a) The ice protection system provides for safe operation; and
(b) The aircraft design must provide protection from slowing to less than the minimum safe speed when the autopilot is operating.

VCA.2545 Pressurized systems elements

Pressurized systems must withstand appropriate proof and burst pressures.

VCA.2550 Equipment containing high-energy rotors

Equipment containing high-energy rotors must be designed or installed to protect the occupants and aircraft from uncontained fragments.

VCA.2555 Installation of recorders

The aircraft must be equipped with a recorder or recorders that:

(a) is installed so as to ensure accurate and intelligible recording and appropriate safeguarding of the data supportive for accident investigation, considering conditions encountered during crash, water immersion or fire;

(b) is powered by the most reliable power source and remains powered for as long as possible without jeopardizing service to essential or emergency loads and emergency operation of the aircraft;

(c) includes features to facilitate the localization of a memory medium after an accident;

(d) is installed so that it automatically records when the aircraft is capable of moving under its own power; and

(e) records in an accepted format;

SUBPART G –FLIGHT CREW INTERFACE AND OTHER INFORMATION

VCA.2600 Flight crew compartment

(a) The flight crew compartment arrangement, including flight crew view, and its equipment must allow the flight crew to perform their duties within the flight envelopes of the aircraft, without excessive concentration, skill, alertness, or fatigue.

(b) The applicant must install flight, navigation, surveillance, and lift/thrust system installation controls and displays so that a qualified flight crew can monitor and perform defined tasks associated with the intended functions of systems and equipment. The system and equipment design must account for flight crew errors, which could result in additional hazards.

(c) the flight crew interface design must allow for continued safe flight and landing after the loss of vision through any one of the windshield panels.

VCA.2605 Installation and operation information

(a) Each item of installed equipment related to the flight crew interface must be labelled, if applicable, as for its identification, function, or operating limitations, or any combination of these factors.

(b) There must be a discernible means of providing system operating parameters required to operate the aircraft including warnings, cautions, and normal indications, to the responsible crew member.

(c) Information concerning an unsafe system operating condition must be provided in a timely manner to the crew member responsible for taking corrective action. The information must be clear enough to avoid likely crew member errors.

(d) Information related to safety equipment must be easily identifiable and its method of operation must be clearly marked.

VCA.2610 Instrument markings, control markings and placards

(a) Each aircraft must display in a conspicuous manner any placard and instrument marking necessary for operation.

(b) The design must clearly indicate the function of each cockpit control, other than primary flight controls.

(c) The applicant must include instrument marking and placard information in the Aircraft Flight Manual.

VCA.2615 Flight, navigation, and powerplant systems instruments

(a) Installed systems must provide the flight crew member who sets or monitors parameters for the flight, navigation, and powerplant, the information necessary to do so during each source of lift and phase of flight. This information must —

(1) Be presented in a manner that the crewmember can monitor the parameter and determine trends, as needed, to operate the aircraft; and
(2) Include limitations, unless the limitations cannot be exceeded in all intended operations.

(b) Indication systems that integrate the display of flight or powerplant parameters to operate the aircraft, or are required by the operating rules, must—

(1) Not inhibit the primary display of flight or powerplant parameters needed by any flight crew member in any normal mode of operation; and
(2) In combination with other systems, be designed and installed so information essential for continued safe flight and landing will be available to the flight crew in a timely manner after any single failure or probable combination of failures.

VCA.2620 Aircraft Flight Manual

The applicant must provide an Aircraft Flight Manual that must be delivered with each aircraft.

(a) The Aircraft Flight Manual must contain the following information:

(1) Aircraft operating limitations;
(2) Aircraft operating procedures;
(3) Performance information;
(4) Loading information; and
(5) Other information that is necessary for safe operation because of design, operating, or handling characteristics.

(b) The portions of the Aircraft Flight Manual containing the information specified in paragraphs (a)(1) through (a)(4) of this section must be approved by the DGCA.

VCA.2625 Instructions for Continued Airworthiness

(a) The applicant must prepare Instructions for Continued Airworthiness that are appropriate for the certification level and performance level of the aircraft.

(b) If Instructions for Continued Airworthiness are not supplied by the manufacturer of an appliance or product installed in the aircraft, the Instructions for Continued Airworthiness for the aircraft must include the information essential to the continued airworthiness of the aircraft.

(c) The Instructions for Continued Airworthiness must contain a Section titled ‘Airworthiness limitations’ that is segregated and clearly distinguishable from the rest of the document. This Section must set forth each mandatory maintenance action required for type certification. This Section must contain a legible statement in a prominent location that reads: ‘The Airworthiness limitations Section is approved and variations must also be approved’.

(d) The applicant must develop and implement procedures to prevent structural failures due to foreseeable causes of strength degradation, which could result in serious or fatal injuries, loss of the aircraft, or extended periods of operation with reduced safety margins. The Instructions for Continued Airworthiness must include procedures developed under VCA.2255.

SUBPART H – Electric Engine/Motor Requirements

Reserved

SUBPART I – Propeller Requirements

Reserved