CIVIL AVIATION
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AUSTRALIA

DESIGN STANDARDS: UNMANNED AERIAL VEHICLES - AEROPLANES

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SUBPART A GENERAL

UA25.1 Applicability

(a) This publication contains a standard for the design and manufacture of unmanned aeroplanes for certification to CAR (1998) 21.25.
(b) Each person who seeks type certification of an unmanned aeroplane of maximum take-off weight of not more than 800 kg under CAR (1998) 21.25, using this publication, shall demonstrate compliance with all the applicable requirements of this publication, except as approved under Equivalent Safety Determination by the Civil Aviation Safety Authority (CASA).
(c) A person seeking type certification of an unmanned aircraft of maximum take-off weight exceeding 800 kg shall demonstrate compliance with sections A, B, D, E, F, and G of this publication and the relevant structural criteria of PICA 26.
(d) The applicant for type certification may nominate variations to the relevant publication, consistent with intended usage of the unmanned aeroplane, for consideration by the CASA.
NOTE: The requirements of this standard are subject to CASA acceptance for the specific design and intended use, CAR (1998) 21.17 refers. The use of some provisions in this document may attract operational limitations on the unmanned aeroplane.

UA25.2 Purpose

(a) The design requirements in this publication are intended for operation of unmanned aeroplanes fitted with Type Certificated Engines (TCEs) under the IFR by day and by night and for limited operation over populous areas.
(b) These requirements may be reduced by negotiation with CASA for day VFR only operations, for operations clear of populous areas or with an Approved Installation Engine accepted by CASA as appropriate for use in the particular aeroplane.

UA25.3 Engine Installations

(a) This publication describes airworthiness requirements for unmanned aeroplanes fitted with either:
(1) A Type Certificated Engine(s) (TCE); or
(2) An Approved Installation Engine(s) (AIE), where the engine(s) or engine installation(s) is(are) accepted by the CASA as appropriate for use in the particular aeroplane type.
NOTE: See Appendix C. Use of an AIE may attract operating limitations.

UA25.5 Minimum Useful Load

(a) Unmanned aeroplanes designed to these requirements shall have a Minimum Useful Load M_u (W_u) computed as follows:
  (1) M_u = (N + 0.3 P) in kg; where P is the rated engine(s) power in KW
  (2) W_u = (N + 0.5 P) in lb; where P is the rated engine(s) power in BHP
  where N = payload (kg or lb).

UA25.7 Maximum Basic Mass (Weight)

The Maximum Basic Mass Mbm (Wbm) includes all operational equipment that is actually installed in the aeroplane. It includes the mass (weight) of the airframe, power plant (including assisted take-off devices), required equipment, optional and specific equipment, fixed ballast, full engine coolant, full hydraulic fluid, full oil and unusable fuel. Thus maximum take-off mass must not be less than;

Maximum Take-off Mass = Maximum Basic Mass + Minimum Useful Load.

SUBPART B FLIGHT

UA25.21 Proof Of Compliance

Compliance with each requirement of this subpart must be demonstrated by test. Tests will systematically investigate each probable mass (weight) and centre of gravity (CG) combination unless it can be reasonably established that a particular mass - CG combination is not critical to the test being performed. Unless otherwise specified, a speed range from stall to V_{NE} shall be considered.

UA25.23 Load Distribution Limits

(a) Ranges of weight and CG position within which the aircraft may be safely operated must be established. Where there is a possibility of large lateral CG movement (for example, with wing tip tank installation) then lateral CG limits must also be investigated.
(b) The load distribution limits may not exceed any of the following:
  (1) The selected limits;
  (2) The limits at which the structure is proven; or
  (3) The limits at which compliance with each applicable flight requirement of this subpart is shown.
  NOTE: Fuel weight may be assumed as 0.72 kg/l for gasoline. If other fuels are used then the density that relates to that fuel should be used.
(c) Fixed and/or removable ballast may be used if properly installed and placarded.
(d) For flight test purposes, an aeroplane weight variation of ± 5% and a CG variation of ± 7% of the CG range is permitted at the test point being

considered provided data reduction can be accurately performed, otherwise a ± 1% variation applies.

UA25.29 Basic Weight And Corresponding CG

(a) The basic weight and corresponding CG must be determined by weighing the aeroplane with:
  - (1) Fixed ballast;
  - (2) Unusable fuel determined under paragraph UA25.959; and
    - (1) Full operating fluids, including;
    - (ii) Oil;
    - (iii) Hydraulic fluid; and
    - (iv) Coolant.

(b) The means of laterally and longitudinally leveling the aeroplane must be specified and the equipment condition at the time of weighing must be specified so that the weighing may be easily repeated and yield the same results within weighing equipment accuracy.

UA25.33 Propeller Speed And Pitch Limits

(a) Propeller speed (RPM) and pitch shall not be allowed to exceed safe operating limits established by the propeller manufacturer under normal operating conditions. In particular the maximum propeller and engine speed shall not be exceeded during;
  - (1) A maximum take-off power climb at 1.3 V_{S1} or V_y where V_y exceeds 1.3 V_{S1}; and
  - (2) Flight at V_{NE} with the throttle closed, the propeller and engine must not exceed 110% of the maximum continuous speed for the propeller and engine (or any other limitation specified by the engine or propeller manufacturer).

  NOTE: V_y is the maximum rate of climb speed.

(b) If a variable pitch or constant speed propeller is fitted then pitch stops must be set up such that the above limits are achieved. Governor failure must be considered.

UA25.45 Performance - General

Unless specified otherwise all performance requirements apply in standard ICAO sea level atmosphere and still air conditions. Speeds shall be given in knots indicated (IAS) and calibrated (CAS).

UA25.49 Stalling Speed

(a) The stalling speed, or minimum flight speed in the landing configuration, V_{S0} must be determined from an approach to the stall at 1 Kt/sec, or less, with:

(1) Engine idling, or stopped, or RPM for zero thrust at not more than 110% stalling speed;
(2) Propeller in take-off position;
(3) Landing gear extended;
(4) Flaps in landing position;
(5) Cowl flaps closed;
(6) CG in the most unfavourable position (generally the forward limit);
(7) Weight close to Maximum Take-off Weight (MTOW), with a correction of results to MTOW; and
(8) The aircraft trimmed to 1.5 times the stalling speed or the minimum trim speed, whichever is the greater.

NOTE: RPM for zero thrust may be calculated using the propeller pitch and setting propeller advance speed equal to 110% of stalling speed. Pitch is based on the zero lift angle of the propeller airfoil section at the 75% radius point.

(b) The stalling speed, or minimum flight speed in the take off configuration, V_{S1} must be determined from an approach to the stall with:
(1) Engine idling, or stopped, or RPM for zero thrust at not more than 110% of stalling speed;
(2) Propeller in take-off position;
(3) Landing gear extended;
(4) Flaps in take-off position;
(5) Cowl flaps in take-off position;
(6) CG in most unfavourable position;
(7) Weight close to MTOW with a correction of results to MTOW; and
(8) The aircraft trimmed to 1.5 time the stalling speed or the minimum trim speed, whichever is the greater.

NOTE: See UA25.201 for stall definition.

UA25.51 Take-Off

Except for rocket assisted or catapult assisted take-off or where some other device is to be used to enable the UAV to attain flight;

(a) The take-off distance shall be measured under the following conditions:
(b) Ground roll distance (or water distance from 3 knots) must be measured;
(c) The airborne distance to 15.2m (50 feet) must be measured;
(d) Take off distance is the sum of airborne and ground distances;
(e) Maximum take-off power must be used with flaps in the take-off position;
(f) The aircraft must be at least $1.3V_{S1}$ over the 15.2m (50 feet) obstacle; and
(g) The test results must be corrected to maximum weight, zero slope and sealed surface conditions.

UA25.65 Climb: All Engines Operating

(a) The aeroplane must have a climb gradient of not less than 8.33 % under the following conditions:
(1) Not more than take-off power;

(2) Landing gear retracted (where applicable);
(3) Wing flaps in take-off position;
(4) Cowl flaps in take-off position;
(5) Airspeed of at least 1.3 V_{S1}; and
(6) Maximum take-off weight and forward CG.

(b) Climb results must be determined as follows:
(1) For TCE aeroplanes, climb results must be corrected to represent a minimum tolerance power engine; or
(2) For AIE aeroplanes, no minimum tolerance power correction is required, however the engine condition must be representative of other installed engines.

UA25.67 Climb: One Engine Inoperative

(a) Multi-engine TCE aeroplanes must be able to maintain altitude at 5000 feet ISA with:
(1) Maximum gross weight, forward CG, in the most favourable flight condition;
(2) The critical engine inoperative and its propeller in the minimum drag position;
(3) Remaining engines at maximum continuous power; and
(4) Landing gear retracted and flaps in most favourable position.

UA25.71 Glide

(a) The maximum horizontal distance travelled in still air, in nautical miles, per 1000 feet of altitude lost in a glide and the speed necessary to achieve this must be determined for:
(1) Single engine aircraft, with the engine delivering no power and its propeller in the minimum drag position and landing gear and wing flaps in the most favourable available position; or
(2) Multi-engine aeroplanes, when fitted with AIE powerplants, with all engines delivering no power and all propellers in the minimum drag position and landing gear and wing flaps in the most favourable available position.
NOTE: Multi-engine aeroplanes with TCE engines must meet the single engine inoperative requirements of UA25.67. Results obtained for multi-engine aeroplanes with AIE powerplants may be considered when determining operating limits for the aeroplane.

UA25.75 Landing

Except where a UAV is designed to be recovered by parachute;

(a) The landing distance should be measured under the following conditions;
(1) Ground roll distance (or water distance) must be measured;

NOTE: For seaplanes, the water distance may be considered finished where the aircraft has slowed to 3 knots.

(2) The airborne distance from 15.2m (50 feet) must be measured;
(3) Landing distance is the sum of the airborne and ground distances;
(4) Engine idling with landing flaps;
(5) Calibrated airspeed must be at least 1.3 V_{S0} over the 15.2m (50 feet) obstacle; and
(6) Test results must be corrected to maximum weight, zero slope and sealed surface conditions.

UA25.77 Baulked Landing

Except where a UAV is designed to be recovered by parachute;

(a) The aeroplane must have a climb gradient of 3 % under the following conditions:
  (1) Take off power on each engine;
  (2) Landing gear extended;
  (3) Wing flaps in landing position; and
  (4) Calibrated airspeed to be 1.3 V_{S0}.

UA25.143 Controllability And Manoeuvrability

Where applicable to the mode of flight;

(a) The aeroplane must be safely controllable and manoeuvrable during:
  (1) Take-off.
  (2) Climb.
  (3) Level Flight.
  (4) Descent.
  (5) Landing (power on and off) and baulked landing with wing flaps extended and retracted, at 1.3 V_{S0} and at 1.3 V_{S0} less 5 knots without moving the trim control.

(b) It must be possible to make a smooth transition from one flight condition to another without exceptional operator skill and without exceeding the aircraft limit load factor. For multi-engine aircraft this must include the sudden failure of one engine.

UA25.145 Longitudinal Control

(a) With flaps retracted or not fitted, it must be possible to:
  (1) pitch the aircraft nose down from V_{S1} to 1.5 V_{S1}
  (2) maintain longitudinal control following sudden loss of power on any engine at any speed

(b) With flaps fitted, it must be possible to:
  (1) pitch the aircraft nose down from V_{S0} to V_F with the flaps down.

(2) With the aircraft trimmed at 1.4 V_{S1} with power off, and also with sufficient power to maintain level flight, extend the flaps fully as rapidly as possible. Transition to 1.4 V_{S0} then fully retract the flaps and transition to 1.4 V_{S1}. Full control must be maintained throughout this manoeuvre.

(3) With the aircraft trimmed at 1.4 V_{S0} with power off and on and with flaps fully extended, fully retract the flaps and transition to 1.4 V_{S1}. Full control must be maintained throughout this manoeuvre without exceeding pilot strength limits.

(4) Sudden loss of power on any engine with any speed or flaps setting must be able to be controlled longitudinally.

UA25.147 Directional And Lateral Control

(a) Reversing the bank from 30 degrees one wing low to 30 degrees the other wing low shall be possible within 4 seconds at 1.3 V_{S0} (Flaps -.if fitted - extended and throttle idle) and at 1.2 V_{S1} (flaps - if fitted - retracted, throttle idle and full).

(b) The aeroplane shall be able to perform the equivalent of a full circuit with either rudder control only or aileron control only. The circuit may be considered to start at an altitude of not more than 7.6m (25 feet) above the ground. All engines operating, differential throttle usage is not permitted, and use of power and flaps must be normal.

(c) Rapid entry and recovery into/from yaw and roll shall not result in uncontrollable flight characteristics.

(d) For multi-engine aeroplanes with any engine inoperative at 1.4 V_{S1}, maximum continuous power on other engine(s) and flaps up, it must be possible to:

(e) Bank the aircraft up to 15 degrees in either direction; and

(f) Yaw the aircraft up to 5 degrees in either direction.

UA25.149 Minimum Control Speed

(a) For multi-engine aircraft, the speed at which control of the aeroplane is retained following the sudden failure of the critical engine must not be greater than 1.2 V_{S1}. After equilibrium has been established following failure, the aircraft must at this speed either have zero yaw or a bank angle of not more than 5 degrees. This must be established under the following conditions;

(1) Maximum available power on the engines;
(2) Centre of gravity on the aft limit;
(3) Minimum critical weight;
(4) Flaps - if fitted - in take-off position;
(5) Landing gear retracted;
(6) Inoperative engine propeller windmilling in the take-off position, or feathered if it has an automatic feathering device; and
(7) The aircraft out of ground effect.

UA25.171 Stability – General

The aeroplane must be longitudinally, laterally and directionally stable under UA25.173 to UA25.251. In addition, the aeroplane must show suitable stability in any condition normally encountered in service.

UA25.173 Longitudinal Stability

Longitudinal stability must be demonstrated with the power at least 75% maximum continuous, flaps up cruise configuration from 1.3 V_{S1} to V_{NE} and power-off landing configuration from 1.3 V_{S0} to V_{FE}.

UA25.177 Static Directional And Lateral Stability

Directional and lateral stability must be demonstrated in the flaps up, power at least 75% maximum continuous, cruise configuration from 1.2 V_{S1} to V_A.

> NOTE: Directional stability is a positive tendency to yaw in the direction of aileron application in a wings level skid when the rudder is released. Lateral stability is a positive tendency to lift the lower wing in a no turn slip when the aileron is released.

UA25.181 Dynamic Stability

(a) Any short period oscillations, not including combined lateral-directional oscillations, shall be rapidly damped.

(b) Any combined lateral-directional oscillations ("Dutch roll") must not affect the ability of the aircraft to be controlled throughout the flight envelope from V_{SI} to V_{NE} and should be damped to 1/10 amplitude in 7 cycles.

UA25.201 Wings Level Stall

(a) It shall be possible to prevent more than 15 degrees of roll or yaw by normal use of controls until the aeroplane stalls under the following conditions;
   (1) Wing Flaps: Full up and full down;
   (2) Landing gear: Retracted and extended;
   (3) Power: Idling and 75% maximum continuous;
   (4) Propeller: Full fine;
   (5) Wings initially level with slip and skid held to a minimum; and
   (6) The aeroplane trimmed at 1.5 V_{S1} or the minimum trim speed, whichever is the greater.
   (7) Height loss during wings level stall must be measured. Refer UA25.1585 (c).

> NOTE: The stall may be considered to have occurred when an uncontrollable pitch down occurs or when the elevator control reaches its stop. Recovery action may commence as soon as this pitch down occurs or when the elevator control reaches its stop. A height loss of over 300 feet is considered excessive.

(b) It must be possible to produce and correct roll by unreversed use of controls up to the time that the aeroplane pitches.

UA25.203 Turning Flight And Accelerated Stalls

(a) After establishing a 30 degree coordinated turn, the turn shall be tightened by use of the elevator until stall occurs. After the stall:
  (1) For 1 Kt/sec or less entry speeds, level flight shall be regained without exceeding 60° of bank in the direction of turn and 30° of bank in the opposite direction;
  (2) For greater than 1 Kt/sec entry speeds, level flight shall be regained without exceeding 90° of bank in the direction of turn and 60° of bank in the opposite direction;
  (3) There must be no uncontrollable pitch up;
  (4) There must be no uncontrollable tendency to spin; and
  (5) The limit load factor and V_{NE} must not be exceeded during recovery.

(b) The stalls of UA25.203(a) shall be performed as follows:
  (1) Up to 1 Kt/sec entry and a 3 to 5 Kt/sec entry;
  (2) Power off and 75% maximum continuous power;
  (3) Flaps up and flaps full down;
  (4) A full aft CG position; and
  (5) Aeroplane trimmed at 1.5 V_{S1} or minimum trim speed, whichever is the greater.

UA25.207 Stall Warning

(a) There must be a clear and distinctive stall warning, with the flaps and landing gear in any normal position, in straight and turning flight.

(b) The stall warning must be furnished to the operator in the control station by a device that will give clearly distinguishable indications.

(c) The stall warning must begin at a speed exceeding the stall speed by a margin of not less than 5 knots, but not more than 10 knots and must continue until the stall occurs.

UA25.221 Spinning

(a) Unless demonstrated incapable of spinning to UA25.221 (c), all aeroplanes must be able to recover from a 1 turn spin in not more than 1 additional turn with controls used in the manner normally used for recovery. In addition,
  (1) V_{NE} and the limit load factor must not be exceeded;
  (2) Flaps retracted and flaps extended must be considered;
  (3) spin recovery must be effected without exceptional operator skill
  (4) Power may be reduced on all engines to affect recovery and flaps may be retracted to affect recovery. If flaps are not retracted during recovery V_{FE} must not be exceeded.

(b) An aeroplane may be designated "characteristically incapable of spinning" if this characteristic can be demonstrated with;
   (1) A weight 5% higher than the maximum take-off weight;
   (2) The CG at least 3% MAC aft of the aft CG limit;
   (3) Elevator travel at least 4^0 more than the specified travel in the direction required to produce a stall; and
   (4) If a rudder is fitted, a rudder travel 7^0 in both directions in excess of the specified normal travel, if this is structurally achievable.

UA25.251 Vibration And Buffeting

The aircraft must be free from excessive vibration or buffeting under any appropriate speed and power condition up to V_D.

SUBPART C STRUCTURE

UA25.301 Loads

Strength requirements are specified in terms of limit loads (the maximum loads to be expected in normal service) and ultimate loads (limit loads multiplied by a prescribed factor of safety).

UA25.303 Factor Of Safety

Unless otherwise provided, a factor of safety of 1.5 must be used for metallic and wooden structures, 1.8 for fibre reinforced primary composite structures subjected to hot, wet structural testing and 2.25 where no specific consideration is made for moisture and temperature during structural testing.

UA25.305 Strength And Deformation

The structure must be able to support limit loads without permanent deformation and without deformations that are large enough to interfere with safe operation.
The structure shall be able to support ultimate loads with a positive margin of safety (analysis), or without failure for at least three seconds (static tests).

UA25.307 Proof Of Structure

(a) Each critical load requirement shall be investigated by either conservative analysis or tests or a combination of both.
(b) The disposable load combinations must include each fuel load in the range from zero fuel to the maximum selected fuel load. If fuel is carried in the wings, the maximum allowable mass (weight) of the aeroplane without any fuel in the

wing tank(s) must be established as “maximum zero wing fuel mass (weight)”, if it is less than the maximum mass (weight).

(c) Certain parts of the structure must be tested as specified in Subpart D.
NOTE: Guidance material on structural testing is contained in Appendix A.

UA25.321 Flight Loads

(a) Flight load factors represent the ratio of the aerodynamic force component (acting normal to the assumed longitudinal axis of the aeroplane) to the weight of the aeroplane. A positive flight load factor is one in which the aerodynamic force acts upwards with respect to the aeroplane.
(b) Compliance with the flight load requirements must be shown at the design maximum mass (weight).
(c) Where disposable loads (such as wing fuel) can relieve critical loads, then the disposable loads must either be considered absent or accounted for in a conservative manner.
(d) The method of load derivation must be specified by the analyst and accepted by the CASA. The analyst is urged to gain this acceptance before proceeding. This also applies to additions made on the basis of intended usage.
(e) Methods of analysis for unconventional layouts such as canards, tandem wings, tailless aeroplanes, cantilever biplanes, multiplanes, T or V tail arrangements, highly swept wings, delta or slatted wings and wing tip fins must be accepted by CASA. Aerodynamic speed control devices will require special consideration.
(f) Aerodynamic data required for the establishment of the loading conditions must be verified by test, calculation or by conservative estimation.

UA25.337 Limit Manoeuvring Load Factor.

(a) The aeroplane must be designed for--
  (1) A limit manoeuvring load factor of 3.8; and
  (2) A negative limit manoeuvring load factor not less than -1.5; or
  (3) 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
    (i) the probability of being exceeded is shown by analysis and flight test to be extremely remote; and
    (ii) The selected values are appropriate to each weight condition between the design maximum and design minimum weights.
  (4) The positive limit manoeuvring load factor with the flaps down is 2.0.

UA25.341 Gust Load Factors

The aeroplane must be designed to withstand, at each critical airspeed with flaps up, the loads resulting from a vertical gust of 50 feet per second.

UA25.347 Unsymmetrical Flight Conditions

The airplane is assumed to be subjected to the unsymmetrical flight conditions of Secs. 23.349 and 23.351. Unbalanced aerodynamic moments about the center of gravity must be reacted in a rational or conservative manner, considering the principal masses furnishing the reacting inertia forces.

UA25.349 Rolling Conditions

The wing and wing bracing must be designed for the following load conditions:

(a) At two thirds design manoeuvring load factor, assume that 100 percent of the semispan wing airload acts on one side of the aeroplane and 75 percent of this load acts on the other side.
(b) The loads specified in UA25.455 resulting from the aileron deflections and speeds, in combination with an aeroplane load factor of at least two thirds of the positive design manoeuvring load factor.

The effect of aileron displacement on wing torsion should be investigated.

UA25.351 Rear Fuselage Loads

(a) The rear fuselage is considered to extend from the wing rear attach fittings aft. The rear fuselage shall be substantiated for the following loads, acting separately:
    (1) The symmetrical loads on the horizontal tail surface found in Section UA25.421;
    (2) The unsymmetrical loads on the horizontal tail surface found in Section UA25.427;
    (3) The loads on the vertical tail surface found in Section UA25.441; and
    (4) Tail wheel loads found in Section UA25.497.

UA25.361 Forward Fuselage And Engine Mount Loads

(a) The forward fuselage and engine mount(s) must be substantiated for:
    (1) The positive and negative manoeuvre and gust load factors, combined with the engine torque resulting from the maximum take-off power factored by:
        (i) for 4 stroke engines; 8, 4, 3 and 2 for 1, 2, 3 and 4 cylinders respectively;
        (ii) for 4 stroke engines; 1.33 for 5 or more cylinders; or
        (iii) for 2 stroke engines; 6 for engines with 1 cylinder, 3 for engines with 2 cylinders or 2 for engines with 3 or more cylinders; or
        (iv) for turbo propeller engines; 1.25.
    (2) For geared engines, the above factor may be varied by dividing the torque factor at the propeller by the gear ratio. In no case may the torque factor be less than 1.33.

(3) An independent side load factor on the engine of 1.5.
(4) Load factors from adjacent undercarriage members, engine power being taken as zero.

UA25.393 Loads Parallel To Hinge Line

Control surfaces, supporting hinge brackets and local attachment to the wing must be designed for an inertial load acting parallel to the hinge line equal to KW, where
K = 24 for vertical surfaces;
K = 12 for horizontal surfaces; and
W = weight (N or lbf) of the control surface being considered.

UA25.395 Control System Loads

The control system and its supporting structure shall be designed for at least 125% of the hinge moments resulting from the control surface loads of UA25.421, UA25.427, UA25.441 and UA25.445.

UA25.409 Tabs

Movable tabs must be designed for an average surface loading not less than 575 Pa (12lb/ft^2).

UA25.421 Horizontal Tail Loads

(a) A horizontal surface balancing load is a load necessary to maintain equilibrium in any specified flight condition with no pitching acceleration.
(b) Horizontal balancing surfaces must be designed for the balancing load occurring at any point on the limit manoeuvring envelope with flaps up.

UA25.427 Horizontal Tail Unsymmetrical Loads

(a) Horizontal surfaces other than main wing and their supporting structure must be designed for unsymmetrical loads arising from yawing and slipstream effects, in the flight conditions specified at UA25.421 as follows:
    (1) 100% of the UA25.421 load on one side and 65% of the UA25.421 load on the other side.

UA25.441 Vertical Tail Loads

(a) Vertical surfaces and their supporting structure must be designed for unsymmetrical loads arising from
    (1) a sudden displacement of the rudder from a condition of zero yaw to full displacement;

(2) a sustained yaw angle of 15 degrees at any point on the flight envelope.

UA25.455 Ailerons

Ailerons must be designed for an average surface loading not less than 575 Pa (12lb/ft^2).

UA25.457 Wing Flaps

Designed flap loading may not be less than 575 Pa (12lb/ft^2).

UA25.459 Outboard Fins And Special Devices

If these items are fitted then loads must be derived from other standards or the literature.

Ground Loads

UA25. 471 General

The limit ground loads specified in this Subpart are considered to be external loads and inertia forces that act upon an aeroplane structure. In each specified landing condition, the external reactions must be placed in equilibrium by the linear and angular inertia forces in a rational or conservative manner.

UA25.473 Landing Gear - Shock Absorption

(a) It shall be determined that the landing gear is capable of absorbing the energy which would result from the aeroplane being landed at its maximum permitted take off weight with an impact vertical load factor of 1.33.

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

UA25.521 Energy Attenuating Systems.

(a) If the landing gear consists of a fixed or deployable energy attenuating system, the aeroplane must be designed to withstand the following loading conditions:

 (1) Up-load conditions in which--

  (i) A load is applied so that, with the aeroplane in the static level attitude, the resultant surface reaction passes vertically through the center of gravity; and

  (ii) ground contact velocity is equal to the greatest probable sinking speed likely to occur at ground contact with energy attenuation systems deployed.

(2) A side-load condition in which--
   (i) A vertical load of 0.75 times the total vertical load specified in paragraph (a) (1) of this section is divided equally among landing gear elements; and
   (ii) For each landing gear element, the load share determined under paragraph (b)(1) of this section, combined with a total side load of 0.25 times the total vertical load specified in paragraph (b)(1) of this section, is applied to that element only.

UA25.572 Flight Structure Fatigue

(a) The flight critical structure must be identified and must be designed so as to minimise the possibility of fatigue failure, in particular, points of high stress concentration must be avoided. Wherever possible, structural redundancy should be provided.

NOTE: Consideration of "Critical Flight Structure" should include at least the wing spars, wing root connections, wing struts, wing-fuselage carry through structure, empennage structure, fuselage structure, engine mounts, flight control surfaces and control systems, flaps and their control systems.

(b) Each structural item identified as flight critical structure must be assessed for fatigue using one of the following methods:
   (1) For conventional metallic (2024, 6061, steel) or composite structural elements, if the Limit tensile stress levels does not exceed 50% of the ultimate allowable for the material then no further fatigue assessment is required. The limit tensile stress level must take into account any stress concentrations in the wing lower spar booms and attachment fittings, wing struts and lower wing-fuselage carry through structures;
   (2) Demonstration of load path duplication, such that the complete failure of any one element of the structure will not lead to the catastrophic failure of the complete structure under limit load conditions. The duplicated structure must be visually inspectable and an inspection, based on this requirement, must be published in the maintenance manual (Ref UA25.1529 (l)); or
   (3) Demonstrate, by analysis or test, the fatigue service life or a fatigue inspection program that will provide timely removal or repair of fatigue damage. The fatigue service life, or inspection program, must be included in the aeroplane maintenance manual (Ref UA25.1529(l)).

   NOTE: A combination of methods is acceptable. Higher stress levels in excess of 50% may be used if it can be demonstrated to be suitable for the particular material used.

(c) Aircraft with externally wire braced wings must be designed such that the aircraft can carry the limit positive load without failure following the failure of a flying wire, and in addition;

(d) Engine mount, empennage and fuselage structures and landing gear structures that form part of the flight structure and that carry tensile loads on landing must be designed to carry 86% of the limit positive flight load after failure of a single element or obvious partial failure of a single element, or alternatively must have an extra factor of 1.33 in addition to other factors for elements that are normally in tension or have tensile bending stress under positive flight loads.

NOTE: Compliance with this clause can be shown by inspection to ensure that, following any single failure, the structure remains determinate (that is, it does not become a mechanism). For example, engine mounts and similar structures that are designed as pin jointed space frames should have at least 4 bolt connections at the firewall, at the engine or any other structural interface and be suitably examined to ensure that a mechanism does not exist. Tailplanes should be 2 spar, or doubly externally braced, or be separable and independent one side from the other, or by any other reasonable means. Fatigue life calculations should be conducted using the methods given in AFS-120-73-2.

SUBPART D DESIGN AND CONSTRUCTION

UA25.601 General

The strength of any component containing a questionable design detail, which has an important bearing on safety and operations or which is not amenable to simple analysis, must be established by test.

UA25.603 Materials And Workmanship

(a) The suitability and durability of materials used in the construction of the critical flight structure must either:
- (1) Meet approved specifications that ensure the strength and other properties assumed in the design data; or
- (2) Be inwards acceptance tested to ensure that properties assumed in design are equalled or exceeded; and
- (3) Where appropriate take into consideration the range of environmental conditions that may reasonably be expected.

NOTE: See Appendix B for guidance on material selection and acceptance.

(b) Workmanship must be of a high standard. Where surface finishes, processes and tolerances are critical these must be clearly specified on drawings.

NOTE: The testing to ultimate of prototype structures may be used as evidence of satisfactory workmanship. Welders must hold welding authorities issued by the CASA, that are appropriate for the classes of welding proposed.

UA25.605 Fabrication Methods

(a) Methods of fabrication shall produce consistently sound structures.
(b) Processes must be specified where required to produce consistently sound flight structures.
(c) All cable assemblies with swaged end fittings must be proof loaded such that the integrity of the swaged fitting is confirmed. For standard cable assemblies, proof load must be taken as 60% of cable minimum breaking load. For push-pull cables, the proof load must exceed 1.1 times limit load and both the cable inner and outer must be tested.
(d) Each new aeroplane fabrication method must be substantiated by a test programme.

UA25.607 Fasteners

(a) Each fastener used in airframe construction must provide 2 methods of locking if the loss of such a fastener would preclude safe flight and landing.
(b) Any fastener subject to rotation must be a bolt or machine screw with a castellated nut and split-pin.
(c) Fasteners and their locking device must not be adversely affected by the environmental conditions associated with application.

NOTE: Tightening the nut down is considered a method of locking. Split pins (cotter pins) are considered as providing both locks. A bolt through a control system rod end, pulley or bearing where the nut can be fully tightened down may be considered not subject to rotation.

UA25.609 Protection Of Structure

(a) Protection of the structure against weathering, corrosion and abrasion, as well as ventilation and drainage shall be provided.

NOTE: Weathering and corrosion protection do not have to be applied where these problems are unlikely; for example, internal timber and composite surfaces and corrosion resistant steel and aluminium alloy types. In applying protection only methods with established acceptability may be used.

(b) Timber structures must internally be well ventilated and drained. Box spars must be vented at each end of each enclosed cell.
(c) Drainage must dispose of internal and external rainwater and fuel, oil and coolant leaks.
(d) Holes for the purpose of internal structural venting and draining must be at least 6mm diameter.

UA25.611 Accessibility

Means must be provided to allow inspection (including inspection of principal structural elements and control systems), close examination, removal and replacement of each part requiring maintenance, adjustments for proper alignment and function, lubrication or servicing.

UA25.612 Provisions For Rigging And Derigging

If it is intended that parts of the structure be assembled and disassembled on a regular basis by unskilled persons, then the structure must be designed such that incorrect assembly is prevented.

UA25.613 Material Strength Properties And Design Values

(a) Strength properties used in the justification of primary structures by analysis must be taken from either:

- (1) A standard aircraft source such as:
  - (i) MIL-HDBK-5 "Metallic Materials and Elements for Flight Vehicle Structure"
  - (ii) MIL-HDBK-17 "Plastics for Flight Vehicles"
  - (iii) ANC-18 "Design of Wood Aircraft Structure"
  - (iv) MIL-HDBK-23 "Composite Construction for Flight Vehicles";
- (2) From data produced by the Standards Association of Australia provided it can be established that these standards account for material variations;
- (3) From properties assumed for the material in the analyses provided a test procedure is used to qualify all materials used in production in stress critical parts; or

  NOTE: Timber and composites fall into this category. Refer to Appendix B for further guidance.

- (4) From well accepted text books on structural analysis.

UA25.621 Casting Factors

For castings where strength is substantiated by at least one static test, and which are inspected by visual methods, a casting factor of 2.0 must be applied in addition to other factors. Factors may be reduced to 1.25 if, in addition to the above, all castings receive a radiographic or approved equivalent non-destructive inspection.

UA25.623 Bearing Factors

(a) Each part that has clearance (free fit) and is subject to pounding and vibration must have an extra factor in bearing of 2.0.

NOTE: This is intended mainly for clearance fit, single bolt, wing joints, engine mount joints and undercarriage joints. A clearance fit is defined here as drilled hole of the nominal fastener size otherwise holes must be reamed to size or drilled for an interference fit.

(b) For factors on control surface hinges and control system joints see UA25.657 and UA25.693.

UA25.625 Fitting Factors

(a) For each fitting (a part or terminal used to join one structural member to another), the following apply:
   (1) 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 -
      (i) The fitting;
      (ii) The means of attachment; and
      (iii) The bearing of joined members unless a bearing factor has already been applied (ref:- UA25.623, UA25.657 and UA25.693)
   (2) 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).
   (3) For each integral fitting, the part must be treated as a fitting up to the point at which the section properties become typical of the member.

UA25.629 Flutter

(a) It must be shown by the methods of paragraph (b) and either paragraph (c), (d) or (e) of this section that the aeroplane is free from flutter, control reversal and divergence for any condition of operation within the limits V-n envelope and at all speeds up to the speed specified for the selected method. In addition
   (1) Safe tolerances must be established for stiffness and mass qualities, which affect flutter, where such qualities are likely to vary critically in production or in service. This would include, but not necessarily be limited to, control cable tension, and control surface balance masses and free play; and
   (2) The natural frequencies and structural stiffness of main structural components must be determined by tests or other approved methods to the extent necessary to obtain inputs to the selected method of (c), (d) or (e) of this section.
(b) Flight flutter tests must be made to show that the aeroplane is free from flutter, control reversal and divergence and to show that:
   (1) Proper and adequate attempts to induce flutter have been made within the speed range up to V_D;
   (2) The vibratory response of the structure during the test indicates freedom from flutter;
   (3) A proper margin of damping exists at V_D; and
   (4) There is no large and rapid reduction in damping as V_D is approached; or

(5) An alternative to paragraphs (1) through to (4) is flight test to V_D with pilot stick raps about all 3 control axes, but limiting V_{NE} to not more than $0.86V_D$ (rather than the more normal 0.9 V_D). In conducting control system raps, the control system must be fitted with a hard stop (eg. pilot's knee) close to the stick rap point. Thus the stick rap consists of a sharp start followed by a sharp stop of the motion.

(c) Rational analysis may be used to predict freedom from flutter, control reversal and divergence, but must cover all speeds up to 1.2 V_D.

(d) Compliance Report No 45 (as corrected) "Simplified Flutter Prevention Criteria" (published by the Federal Aviation Administration) may be accomplished to show that the aeroplane is free from flutter, control reversal, or divergence if:

(1) V_D/M_D for the aeroplane is less than 260 knots (EAS) and less than Mach 0.5;

(2) The wing and aileron flutter prevention criteria, as represented by the wing torsional stiffness and aileron balance criteria, are limited in use to aeroplanes without large mass concentrations (such as engines, floats, or fuel tanks in outer wing panels) along the wing span; and

(3) The aeroplane:

(i) Does not have a T-tail or other unconventional tail configurations;

(ii) Does not have unusual mass distributions or other unconventional design features that affect the applicability of the criteria; and

(iii) Has fixed-fin and fixed-stabiliser surfaces.

(e) Compliance with the criteria specified in one of the following sub-paragraphs subject to the conditions of paragraph (d)(1), (d)(2), (d)(3) and (g) may be taken to show that the aeroplane is free from flutter, control reversal and divergence;

(1) BCAR-K; or

(2) DLR-FB 89-56

NOTE: This is not an exhaustive list. Other methods, such as one based on the Broadbent criteria, may be developed on a case by case basis by negotiation with CASA.

(f) Moveable trim tabs must be fully mass balanced about the tab hinge line, unless the tab design incorporates other features that will prevent flutter in the event of any single failure in the tab system.

(g) For aeroplanes relying on fail safe or damage tolerance features to show compliance with UA25.572, the selected method of (c), (d) or (e) must take into account expected loss of structural stiffness with the rigidity and mass balance criteria (pages 4-12), in Airframe and Equipment Engineering in the partially failed condition.

UA25.641 Wings - Proof Of Strength

(a) The limit load capacity of wings must be demonstrated by test. During this test the following will apply:

(1) The wing(s) will be connected to the fuselage or a structurally representative segment of fuselage such that the wings and wing - fuselage carry through structure are simultaneously tested;

(2) The ailerons and aileron control system that lies in the wing shall be installed for the test and they must continue to operate without jamming or excessive friction whilst the limit load is applied; and
(3) Wings with integral fuel tanks must be tested with:
(i) the fuel tank pressure equal to that caused by the load factor being considered; and
(ii) the fuel tank unpressurised.

NOTE: Some leakage in structural prototype tanks is allowed provided leakage is unrelated to the load being applied and provided the pressure differential is maintained.

(b) The ultimate strength of stressed skin wings must be shown by test.
NOTE: Where it is intended to produce 3 or less examples of a type, and the Type Certificate is limited accordingly, this requirement may be waived.
(c) Where limit load testing only is conducted (that is, there is no ultimate load test) the test limit load must be increased by a factor of 1.15.
(d) Fibre reinforced composite components must be temperature conditioned prior to structural testing.
NOTE: Recommended procedures for structural testing, including temperature conditioning of fibre composite components, are provided in Appendix A.

UA25.651 Control Surfaces - Proof Of Strength

(a) The limit load capacity of control surfaces must be demonstrated by test. For the purposes of this paragraph:
(1) The tail plane and elevator will be tested together for the loads specified in UA25.421 and UA25.427. The loads will be applied both upwards and downwards unless the tailplane and elevator and fuselage structure layout make this unnecessary;
(2) The fin and rudder will be tested together for the loads specified in UA25.441. The loads will be applied left and right unless the structural layout is such that this is unnecessary; and
(3) The ailerons will be tested to the load specified in UA25.455. This load must be applied up and down.
(b) In conducting empennage load tests, the empennage must be attached to the fuselage and the fuselage supported at the most aft wing attach point such that the empennage and fuselage are loaded simultaneously.
(c) The aileron must be attached to the wing prior to testing the aileron.
(d) For each of the tests in this paragraph a sufficient part of the flight controls must be installed so that:
(1) the moveable control surface is loaded in a representative way; and
(2) the moveable control surface can be sufficiently cycled through its range of movement to show that, under the limit load, it is free of jamming and excessive friction.
(e) The ultimate strength of control surfaces and stressed skin aft fuselage assemblies must be demonstrated by test.
NOTE: Where it is intended to produce 3 or less examples of a type, and the Type Certificate is limited accordingly, this requirement may be waived.
(f) Where limit load testing only is conducted (that is, there is no ultimate load test) the test load must be increased by a factor of 1.15.

(g) Fibre reinforced composite components must be temperature conditioned prior to structural testing.
NOTE: Refer to Appendix A.

UA25.655 Control Surface Installation

(a) Moveable tail surfaces must be installed so that there is no interference between any surface or their bracing when controls are simultaneously moved through their full movement range.
(b) If an adjustable stabiliser is used, it must have stops that will limit its range of travel so as to allow safe flight and landing following failure in the trim control circuit.

UA25.657 Hinges

(a) Control surface hinges, except ball and roller bearing hinges, must have an ultimate factor of safety in bearing of 6.67 under flight loads.
(b) For ball and roller bearing hinges, the approved rating of the bearing may not be exceeded. Alternatively, bearing manufacturers data may be used to assure a bearing life of not less than 1000 hours with a 95% probability of survival.
(c) Hinges must have enough strength and rigidity to react loads parallel to the hinge line. Refer to UA25.393.

UA25.659 Mass Balance

(a) The supporting structure and attachment of control surface mass balance weight must be designed for limit loads acting separately of:
    (1) 24g normal to the plane of the control surface;
    (2) 12g fore and aft; and
    (3) 12g parallel to the hinge line.

UA25.671 Control Systems - General

Each control must operate smoothly and positively enough to allow proper performance of its functions.

UA25.673 Primary Flight Controls

(a) The primary flight controls are those used for the immediate control of pitch, roll and yaw.
(b) The design of the primary flight controls must minimise the likelihood of complete loss of lateral or directional control in the event of any single failure in these control systems.

UA25.675 Control System Stops

Each aerodynamic surface control system must have stops that positively limit surface movement.
Each control stop must be able to withstand any loads corresponding to the design conditions for the control system.

UA25.677 Trim Systems

If a trim system is used it must be demonstrated that the aeroplane is safely controllable, and the operator can perform all manoeuvres and operations necessary to effect a safe landing, following any probable trim system failure that could reasonably be expected to occur in service.

UA25.681 Control System Limit Load Static Tests

(a) Limit load tests must be conducted on elevator, aileron, rudder and flap control systems.
(b) The limit loaded system must be cycled through its available range of movement without:
  (1) Jamming;
  (2) Excessive friction; and
  (3) Interference with other controls.
  NOTE: If under the limit load, friction is such that controls cannot be readily moved so as to produce a resultant movement at the aerodynamic surface, then friction is excessive.
(c) The primary flight control system stretch under the limit load may not exceed the point where there is less than 10% effective control system movement at the point of attachment of the control system to the control surface.
(d) Where limit load testing only is conducted, that is, there is no ultimate load test, the test load must be increased by a factor of 1.15.
(e) Fibre reinforced composite components that are exposed to direct sunlight must be temperature conditioned as detailed in Appendix A.

UA25.685 Control System Details

(a) Each detail of each control system must be designed and installed to prevent jamming, chafing and interference from payload, loose objects or the freezing of moisture.
(b) There must be a means to prevent entry of foreign objects into places where they would jam the system.
(c) There must be a means to prevent slapping of cables and rods against other parts.
(d) Each element of the flight control system must have design features, or must be distinctively and permanently marked to minimise the possibility of incorrect assembly.

UA25.687 Spring Devices

The reliability of any spring device used in the control system including its susceptibility to icing must be established by test simulating service conditions unless failure of the spring will not cause flutter or unsafe flight characteristics.

UA25.689 Control Cable Systems

(a) There must be a means for visual inspection of the cable at each fairlead, pulley, terminal and turnbuckle.
(b) Fairleads must be installed so that they do not cause a change in cable direction greater than 3^{o}.
(c) Where turnbuckles are attached to parts having angular motion, the available movement between the turnbuckle and the part must be large enough to prevent binding.
(d) Each kind and size of pulley must correspond to the cable size and control system load with which it is used. Each pulley must have a closely fitting guard to prevent the cables from being misplaced or fouled even when the cable is slack. Each pulley must lie in the cable plane in the neutral position with not more that 3^{0} of pull off when fully deflected.
(e) Clevis pins may be used in shear applications only.

UA25.693 Control System Joints

Control system joints that are subject to angular motion must have an ultimate factor of safety of 3.33 in bearing. This does not apply to ball or roller rod ends, which may not be loaded beyond the manufacturers rated capacity.

UA25.701 Flap Interconnection

(a) Where flaps are fitted, motion of flaps on opposite sides of the aircraft must be synchronised by a mechanical interconnect.
(b) The flap operating and interconnect mechanism must be designed for 100% of the flap loads given in UA25.457 acting on one side and 70% of these loads acting on the other side.

UA25.787 Payload Compartment

(a) Each payload compartment must be designed for its placarded maximum weight of contents under the load factors of UA25.337, UA25.341, UA25.479 and UA25.561.
(b) The payload compartment must have provisions for securing the load.
(c) Payload compartments must prevent payload from moving and fouling flight and engine controls, pipes and wiring.

UA25.863 Flammable Fluid Fire Protection

(a) The risk of fire resulting from flammable fluid leakage must be minimised by:
  (1) Providing ventilation and drainage close to lines.
  (2) Passing lines under electrical cables.
  (3) Keeping flammable fluid line unions away from electrical junction boxes such that leakage under likely pressure will not lead to contact with electrical junctions.
  (4) Covering electrical junctions which are in the same area as flammable fluid lines.
  (5) Locating flammable fluid lines where they will not be damaged by payload or minor maintenance operations.

UA25.865 Fire Protection Of Flight Controls & Structure

Flight controls, and other flight structure located in the engine compartment must be constructed of fireproof material or shielded so that they will withstand the effect of fire. See also UA25.1193 (d).

SUBPART E POWERPLANTS

UA25.903 Engines

(a) Aeroplanes for certification with a TCE engine(s) must be fitted with an engine that has been type certified in accordance with FAR 33, BCAR C, CAR 13, CAR (1998) Part 32, CAR (1998) Part 33, JAR E or JAR 22H.
(b) Aeroplanes for certification with an AIE engine(s) must be fitted with an engine acceptable for the type. Appendix C details items to be considered in determining suitability.
(c) For multi-engined aircraft, engines must be arranged such that any failure on one engine will not cause any other engine to fail.
(d) The engine installation must be such that the risk of mechanical damage and fire during starting and stopping is minimised. If special procedures are required these must be placarded on the airframe.

UA25.905 Propellers

(a) TCE aeroplanes must be fitted with either:
  (1) A propeller that has been type certified in accordance with either FAR Part 35, BCAR Section C, JAR Section P, JAR Part 22J or CAR (1998) Part 35; or,
  (2) A propeller approved in accordance with Appendix D of this document.
(b) AIE aeroplanes must be fitted with a propeller approved as suitable for the type. Appendix D details items to be considered in determining suitability.

(c) Engine power and propeller shaft rotational speed may not exceed the limits for which the propeller is certificated or approved.

UA25.907 Propeller Vibration

(a) Each propeller with metal or composite blades, or with highly stressed metal or composite components, must be shown to have maximum vibration stresses that do not exceed the endurance limit for the material.
NOTE: The endurance limit may be taken as 45% of the ultimate tensile stress. Proper account must be taken for stress concentration factors.
(b) Except as noted in (e) and (d) below, compliance with (a) must be shown by strain gauging a propeller noting that:
  (1) For tractor propeller installations where the propeller is at least one propeller radius forward of the wing leading edge, only the engine-propeller combination need be considered.
  NOTE: This means that for a particular engine-propeller combination which has been previously shown to comply with this paragraph no further testing is necessary.
  (2) For pusher propeller installations, or tractor propeller installations where the propeller is less than one propeller radius forward of the wing leading edge, the engine-propeller-airframe combination must be considered.
(c) Compliance with (a) need not be shown if:
  (1) The propeller is a fixed pitch wooden propeller of all wooden construction; or
  (2) The propeller is bench run under the following conditions for 50 hours:
    (i) The propeller is operated throughout at the rated RPM; and
    (ii) An arc of 20° is blanked out, the propeller missing the blanking by not more than 13mm (0.5"); and
    (iii) The engine-propeller combination is oscillated in pitch or yaw such that the peak angular velocity is not less than 1 radian/sec; and
    (iv) Half of the bench run is conducted at the coarsest pitch setting and the other half at the finest pitch setting; and
    (v) After the bench run an inspection is conducted to ensure that the propeller is free of cracking and wear is minimal.

UA25.943 Negative Acceleration

No hazardous malfunction of an engine may occur when it is exposed to a momentary negative acceleration.
NOTE: A hazardous malfunction is one where the engine cannot subsequently be re-started before landing and run up to full power.

UA25.951 Fuel System - General

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 likely operating condition, including the manoeuvres for which certification is requested.

UA25.954 Fuel System Electrical Bonding

All fuel system components including the tank and tank filler neck must be electrically bonded together.

> NOTE: Care must be taken to ensure that joints are not insulated by protective treatments or oxide coats.

UA25.955 Fuel Flow

(a) For gravity systems, the fuel flow rate must be at least 150% of the take-off fuel consumption.
(b) For fuel pump systems, the flow rate for each pump must be at least 125% of the take-off fuel consumption.
(c) If the engine can be supplied by fuel from more than 1 tank, it must be possible in level flight to regain full power in not more than 10 seconds after engine malfunction due to fuel depletion in any tank by switching to a tank with remaining fuel.

UA25.959 Unusable Fuel And Fuel Supply In Unbalanced Flight

(a) The unusable fuel quantity for each tank must be established as not less than that quantity at which the first malfunctioning occurs under take-off climb, cruise and approach configurations. It is acceptable to determine unusable fuel quantity in a wings level, balanced flight attitude.
(b) The engine must be able to operate at take-off power, without malfunctioning, for at least 30 seconds under the following conditions:
   (1) The tank outlet is uncovered as a result of unbalanced flight, with only fuel contained downstream of the tank outlet available. After returning to balanced flight the fuel system must self prime within one minute to a point where this requirement could again be met; or
   (2) With fuel provided only from a well at the bottom of each primary supply fuel tank, the aircraft is flown in a 5° unbalanced wing down sideslip.
(c) Compliance with UA25.959 may be shown by calculation.

UA25.963 Fuel Tanks - General

(a) The fuel tank, other than wing integral tanks, must be able to withstand the following structural loads:
(b) Flight and ground loads arising from UA25.337, UA25.341 and UA25.473.
(c) An independent side load factor of 1.5g.
(d) An independent fore and aft load of 2.0g.
(e) Each integral fuel tank must have adequate facilities for internal inspection and repair.

(f) The total useable capacity of fuel tanks must be enough for at least one hour operation at maximum continuous power.
(g) No fuel tank may form part of a firewall or be located inside an engine compartment. Fuel tanks must be separated from firewalls by at least 25mm (1 inch). No fuel tank may be located where a fire is likely to impinge on it.
(h) Each flexible tank liner must be of an acceptable kind and enclosed within a rigid supporting structure.

UA25.965 Fuel Tank Tests

(a) Each non-integral fuel tank must be able to withstand an ultimate pressure of 24 kPa gauge (3.5 psig). Integral fuel tanks must be able to withstand the pressure generated by the highest limit load factor without leaking (refer to UA25.641 (a) (3)).
(b) Fuel tanks located inside the fuselage must be able to withstand an ultimate pressure generated by a 15g forward acceleration.

UA25.967 Fuel Tank Installation

(a) Each fuel tank must be supported so that loads resulting from the weight of fuel are not concentrated on unsupported tank skin. In addition:
    (1) There must be pads, if necessary, to prevent chafing between each tank and its supports; and
    (2) Supporting pads must be of a non-absorbent material.
(b) Each compartment containing a fuel tank must be ventilated and drained overboard. Each compartment adjacent to an integral fuel tank must be vented and drained.
    NOTE: The intent here is to prevent pooling of leaked fuel.
(c) The fuel system must have a means of indicating fuel quantity visible to the operator in the control station.
(d) The operator must be able to visually check the fuel tank quantity during a pre-flight inspection to confirm enough fuel for flight.

UA25.971 Fuel Tank Sump

(a) Each fuel tank must have a drainable sump into which water will drain in the ground attitude with a ground slope of 2^o in any direction with an effective capacity in normal ground and flight attitudes of 0.25% of the tank capacity or 0.24 litre whichever is the greater, unless:
    (1) Each tank outlet is located so that in the normal ground attitude, water will drain from all parts of the tank to a sediment bowl or chamber with the aircraft in the ground attitude with a ground slope of 2^o in any direction. This sediment bowl or chamber must have a capacity of not less than 0.24 litres.
    (2) For wings tanks with no dihedral, a water drain must be located at one extreme side of the tank and the tank outlet and sump at the other

extreme of the tank, the sump meeting the capacity requirements of this paragraph.

(b) Each sump or sediment bowl drain must comply with UA25.999.

(c) It must not be possible for the engine to draw fuel from the sump or sediment bowl in the normal flight attitude.

UA25.973 Fuel Tank Filler Connection

(a) Each fuel tank filler point must be marked at or near the filler with:
   - (1) The word "FUEL";
   - (2) The fuel grade and mixing ratio if pre-mixed fuel-oil is used; and
   - (3) The useable tank capacity.

(b) The filler must be located on the outside of the aeroplane, such that spilled fuel will not enter the aeroplane.

(c) Each filler must have an electrical earthing point close to the filler, marked "EARTH". The earthing point must be electrically bonded to the rest of the fuel system and to the aircraft. Conductor cross section must be not less than 1.3 sq mm.

(d) Each filler cap must provide a fuel tight seal, however small openings for vents and fuel gauges through the cap are permitted.

UA25.975 Fuel Tank And Carburettor Vapour Vents

(a) Each fuel tank must be vented from the top of the tank.

(b) Each vent must be located and constructed in a manner that minimises the possibility of it being obstructed by ice or other foreign matter.

(c) Each vent must be constructed to prevent siphoning of fuel during normal operation.

(d) There may be no undrainable points in any vent line in the ground or normal flight attitude.

(e) Fuel tank vents must vent clear of the aeroplane. Carburettor vents must vent clear of exhausts and electrical equipment.

UA25.977 Fuel Tank Outlet

(a) There must be a finger fuel strainer which protrudes inwards into the fuel tank at each fuel outlet. The strainer must be constructed of corrosion resistant metal mesh of 8 to 16 meshes per 25mm (1").

(b) The clear area of each strainer must be at least 5 times the area of the outlet line.

(c) The diameter of each strainer must be at least that of the fuel tank outlet.

(d) Each finger strainer must be accessible for inspection and cleaning.

UA25.991 Fuel Pumps

(a) Where a fuel pump is required to supply fuel to an engine at least one pump must be provided for each engine and each pump must be driven by its respective engine. This is the main fuel pump.
(b) In addition, an emergency pump with an independent power source to the main pump must be provided so that an engine will operate normally following the failure of its main pump.

UA25.993 Fuel System Lines And Fittings

(a) Each fuel line must be installed and supported to prevent excessive vibration and to withstand loads due to accelerated flight conditions.
(b) Each fuel system component must be manufactured from corrosion resistant materials.
(c) Each fuel line connected to components between which relative motion could exist must have provisions for flexibility.
NOTE: Crash conditions where large angular movement between the wing and fuselage occurs and where fuselage distortion may occur must be considered.
(d) Each flexible hose must be shown suitable for the particular application.
NOTE: Unreinforced rubber or plastic hose is unsuitable for fuel systems.
(e) Each fuel line and fitting in any area subject to engine fire conditions must be at least fire resistant.
NOTE: Fire resistance is defined as the ability to withstand a flame temperature of 1093^o C (2000^o F) for five minutes and remain functional.
(f) Fuel lines must be routed such that fuel leakage is unlikely to impinge on exhaust systems or electrical components.
(g) A fuel filter must be provided so as to remove fine particles from fuel. This filter must be easily inspectable and replaceable.
NOTE: Filters must be of the metal or nylon mesh type with a hole opening size of between 0.08 mm and 0.23mm. Paper type filters may not be used.
(h) Where fuel hoses are pushed over nipples and secured with hose clamps, the nipples must have a raised ridge on its end to help secure the hose once the clamp has been tightened.

UA25.999 Fuel System Drains

(a) The fuel system up to the point where it attaches to the engine must be able to be completely drained in the normal ground attitude.
(b) Each fuel drain must:
   (1) Be easily accessible;
   (2) Discharge clear of the aircraft; and
   (3) Have an automatic means for positive locking in the closed position.

UA25.1011 Oil Systems - General

(a) If an engine is provided with an 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 an endurance that exceeds fuel system endurance. NOTE: This may be based on measured oil system consumption during a flight test program.
(c) If an engine depends upon a fuel/oil mixture for lubrication then a reliable means of of providing it with the appropriate mixture must be established. Proper account must be taken of:
  (1) Engine tolerance to non-optimum fuel/oil ratio;
  (2) Refuelling procedure and introducing the appropriate amount of oil; and
  (3) Means by which the operator may check the fuel contains an adequate mixture of oil.

UA25.1013 Oil Tanks

(a) Each oil tank (or sump which acts as a tank) must meet the requirements of UA25.967(a), (b), (c) and (f).
(b) Each oil tank, unless part of the engine, must be designed for the loads of UA25.963.
(c) Oil tank quantity must be easy to check without having to remove any cowling parts (with the exception of access covers) or to use any tools.
(d) An oil tank that is not part of an engine which is installed in the engine compartment must be fireproof.

UA25.1015 Oil Tank Tests

Oil tanks that are not part of the engine must be able to withstand an ultimate pressure of 35 kPa (5psig).

UA25.1017 Oil Lines And Fittings

(a) Oil lines must comply with UA25.993, except that an oil filter is not mandatory.
(b) Oil tank and engine crankcase 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 will not constitute a fire hazard if foaming occurs; and
  (3) The breather must not discharge into an engine air inlet.

UA25.1019 Oil Strainer Or Filter

Each oil strainer or filter in the power plant 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.

UA25.1021 Oil System Drains

(a) A drain must be provided to allow draining of the oil tank clear of the aircraft. Each drain must:
   (1) Be easily accessible with no more than cowl removal; and
   (2) Have a means for positively locking in the closed position.

UA25.1023 Oil Radiators

Each oil radiator and its supporting structure must be able to withstand the loads of UA25.963(a).

UA25.1027 Propeller Feathering System

For an aircraft with a propeller feathering system that depends on engine oil to feather the propellers, there must be a system to trap sufficient oil within the oil tank to achieve feathering of the propeller if the oil supply becomes depleted due to any failure within the oil system, other than the tank itself.

UA25.1041 Cooling

(a) Each powerplant cooling system must be able to maintain the temperatures of powerplant components within the limits established for these components under critical surface (ground or water) and flight operating conditions for which certification is required and after normal shutdown. Powerplant components to be considered include but may not be limited to engines, gearboxes, auxiliary power units, and the cooling or lubricating fluids used with these components.
(b) Compliance with sub-paragraph (a) of this paragraph must be shown in tests conducted under the conditions prescribed in that paragraph.

UA25.1061 Liquid Cooling

(a) Each coolant tank and radiator must be able to carry the loads of UA25.963(a).
(b) Each coolant system must be designed such that air cannot become trapped within the system.
(c) Each coolant tank or radiator header tank must have a capacity that is at least 10% of the rest of the coolant or as recommended by the engine manufacturer.
(d) The coolant system must comply with UA25.993 except that fire resistance and a filter are not required.
(e) Flammable coolants must not be used.
(f) The coolant system must be provided with a method of draining that completely drains the system clear of the aircraft and has a means to positively lock it closed.
   NOTE: This may be achieved by removal of a hose provided spillage does not accumulate within the aircraft.

(g) Coolant tanks, if not supplied by the engine manufacturer, must withstand a pressure of 1.5 times the coolant system pressure or 24 kPa, whichever is the higher.

(h) A thermostat, if fitted, must either:
  (1) Be such that it always fails to the open position; or
  (2) Be fitted with a manually operated by-pass valve that can be controlled by the operator, such that with the thermostat fully closed and the bypass fully open the cooling requirement of UA25.1041 may be met.

(i) If supplementary electric fans are supplied, the requirements of UA25.1041 must be met with the fan off.
NOTE: This means that supplementary fans may only be used for ground cooling purposes.

UA25.1091 Engine Air Induction

(a) Each positive displacement engine must be provided with 2 separate air intake air sources. The unheated air source, which is the source which is used for normal operation, is the primary air source. The other source is the alternative source.

(b) Air filters may be installed on the primary source only.

(c) Engines with fuel injection must be fitted with a spring loaded door on the alternative source which will open automatically if the primary source becomes blocked. The alternative source must draw its air from a location where air heating may be expected.
NOTE: This location could be downstream of an air cooled cylinder or behind a radiator.

(d) Four stroke engines fitted with carburettors must have a controllable air pre-heater that, in air with no signs of visible moisture at -1^0C, provides a 50^0C air temperature rise at 75% of maximum continuous power.
NOTE: Where there is no power curve available for the engine then 90% of maximum take off engine RPM may be used as equivalent to 75% maximum continuous power.

(e) Two stroke engine fitted with carburettors must have a controllable or automatic alternative air source which draws air from a location where air heating may be expected.
NOTE: Automatic systems come into operation when the throttle is less than full open.

UA25.1101 Carburettor Air Preheater Design

(a) Each carburettor air pre-heater must be designed and constructed to:
  (1) Ensure ventilation of the preheater when the engine is operated on cold air;
  (2) Allow visual inspection of the exhaust manifold that it surrounds; and
  (3) Allow visual inspection of critical parts of the preheater itself.

UA25.1121 Exhaust System - General

(a) Each exhaust system must ensure safe disposal of exhaust gases without fire hazard.
(b) 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.
NOTE: The surface auto-ignition temperature of gasoline may be taken as 360°C, so an exhaust stack or shield that does not exceed 300°C where leakage may occur may be considered acceptable.
(c) Each exhaust system component must be separated by fireproof shields from adjacent flammable parts of the aeroplane.
(d) No exhaust gases may discharge dangerously near any oil or fuel system drain.
NOTE: 'Dangerously near' may be taken as 381mm (15") upstream and 76mm (3") across stream from the point where exhaust gases start mixing with outside air.
(e) Each exhaust system must be ventilated to prevent points of excessively high temperature.

UA25.1123 Exhaust Piping

(a) The exhaust system must be fireproof and must have a means to prevent failure due to expansion.
(b) Exhaust piping must be supported to withstand vibration and inertia loads that may occur in normal operation.
(c) Parts of the exhaust system connected to components between which relative motion could exist must have a means for flexibility.
(d) Exhaust systems for 4 stroke engines must be self draining.

UA25.1141 Power Plant Controls - General

(a) A means of providing control input necessary for the correct functioning of the powerplant(s) under all flight conditions shall be provided for the operator at the control station
(b) 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.
(c) Each control must be able to withstand operating loads without excessive deflection.
(d) There must be a means to indicate to the operator the position of any control necessary for the correct functioning of the engine(s)

UA25.1165 Engine Ignition Systems.

(a) Each battery ignition system must be supplemented by a generator (or alternator) that is automatically available as an alternative source of electrical energy if any battery becomes depleted. In addition:

(b) The battery, when fully charged, must have sufficient energy for one hour of operation with ignition only on.
(c) Each generator must have sufficient power to provide ignition and essential service power.
NOTE: This may be demonstrated by starting the engine then disconnecting the battery or turning the master switch OFF.
(d) A warning when there is not a charging current from the generator or the alternator to the bus shall be provided for the operator at the control station

UA25.1182 Nacelle Areas Behind Firewalls

Compartments, lines and fittings behind engine compartment firewalls must be constructed of materials and located such that an engine fire will not endanger the aircraft.
NOTE: This may be determined by inspection and comparison with current good practice.

UA25.1191 Firewalls.

Each engine compartment must be separated from the rest of the airframe by a firewall, except for open type engine installations where the airflow will carry any engine fire away from adjacent structure.
The firewall must be fireproof. The following materials are accepted as fireproof:
Stainless steel, 0.38mm (0.015") minimum thickness; and
Mild steel coated with aluminium or zinc, terne plate or monel metal 0.46mm (0.018") minimum thickness.
Pipe and hose fittings through the firewall must be steel or copper based.
Other openings in the firewall must be sealed with fireproof seals or compounds.

UA25.1193 Cowling And Nacelle.

When an engine installation is cowled:
Each cowling must be constructed and supported so that it can resist vibration and air loads to which it may be subjected.
NOTE: Comparison with similar cowls of satisfactory service history is acceptable.
There must be a means for rapid and complete drainage of each part of the cowl in the normal ground and flight attitude. No drain may discharge where it will cause a fire hazard.
Each cowl and each part of the aircraft 600mm (23.6") aft of an opening in a cowl must be fire resistant.
NOTE: Aluminium sheet is considered fire resistant. If fibreglass is used then the resin must be either fire resistant or rendered fire resistant. Derakane 510-A40 is a fire resistant resin. If epoxy resin is used, addition of 3% by resin weight of antimony trioxide or antimony pentoxide or 10% by resin weight of aluminium trihydrate will render the resin fire resistant. Note that antimony trioxide and antimony pentoxide are registered carcinogens.

Engine mounts must be constructed of fire proof materials. The engine must be retained if shock mounts supporting the engine are burnt away.

UA25.1195 Noise And Engine Emissions.

NOTE: A type certificate for an aircraft in the restricted category does not certify that it complies with the Air Navigation (Aircraft Noise) Regulations, the Air Navigation (Aircraft Engine Emissions) Regulations or any other applicable Commonwealth legislation. Compliance with those regulations or other applicable Commonwealth legislation may be required before the aeroplane can be legally operated.

SUBPART F EQUIPMENT

UA25.1301 Equipment - General

(a) Each item of installed equipment must:
  (1) Be of a kind and design appropriate to its intended function;
  (2) Be installed according to limitations and conditions specified by the equipment manufacturer; and
  (3) Function properly when installed and not constitute a hazard to safe operation, including probable malfunctions and failure.
(b) All software should:
  (1) be designed in accordance with aeronautical industry standards;
  (2) demonstrate robustness and redundancy; and
  (3) be capable of validation and verification.

NOTE: Proper functioning should be considered under all reasonably probable operating conditions including operations in areas subject to electromagnetic interference. Testing for a particular condition is not required unless reasonable doubts exists as to a particular set of conditions that exists.

UA25.1303 Flight And Navigation Sensors.

(a) Sensors capable of relaying the following flight and navigation information to the ground control station must be installed on the aircraft:
  (1) indicated airspeed;
  (2) altitude (corrected for atmospheric pressure variation);
  (3) magnetic direction; and
  (4) ground position

NOTE:
  (i) The airspeed indicator and altimeter must be calibrated for every aircraft.
  (ii) Alternative systems may be used to provide the required information where it can be shown that information provided is of

a similar or better accuracy than that provided by conventional systems.

UA25.1305 Power Plant Sensors.

(a) Sensors capable of relaying the following power plant information to the ground control station must be installed on the aircraft:
- (1) Such pressure, temperature and RPM indications as the engine manufacturer may require or as necessary to operate the engine within its limitations;
- (2) A fuel quantity indicator for each tank (Refer UA25.967 (d), (e) and (f)); and
- (3) An oil quantity indicator for each tank (Refer UA25.1551).

UA25.1307 Miscellaneous Equipment

(a) Except as permitted by CASA, an unmanned aeroplane requiring certification must be fitted with the following miscellaneous equipment:
- (1) a system for rebroadcast of two way radio communications;
- (2) two systems for radio navigation designed and installed so that failure of one system will not preclude operation of the other system;
- (3) programmable transponder with mode C capability

UA25.1309 Equipment, Systems, And Installations.

(a) The aeroplane systems and associated components, considered separately and in relation to other systems, must be designed so that the occurrence of any failure condition which would prevent the continued safe flight and landing or safe recovery of the aircraft is extremely improbable; and

(b) Compliance with the requirements of sub-paragraph (a) of this paragraph must be shown by analysis and, where necessary, by appropriate ground, flight, or simulator tests.

UA25.1322 Warning, Caution And Advisory Indicators.

(a) If coloured warning, caution or advisory indicators are installed in a ground control station, they must be:
- (1) Red, (indicating a hazard which may require immediate action);
- (2) Amber, (indicating the possible need for future corrective action);
- (3) Green, for safe operation; and
- (4) Any other colour, including white, for indications not described in (a) through (c) of this paragraph provided the colour differs sufficiently from colours specified in (a) through (c) so as to avoid possible confusion.

UA25.1323 Airspeed Indicating System.

(a) The airspeed system must be calibrated. The system error, including position error but excluding instrument calibration error, may not exceed 5 knots.
NOTE: The pitot source should be located where large variations of incidence are unlikely. These positions are under the wing or back from the nose on pusher designs. The static source should be located in a position where the effect of variations of tolerance will be minimal. If a pitot-static design cannot be assessed as being tolerant to manufacturing variations by comparison with other consistent error designs, then tolerances should be established such that a one knot error variation is achieved.

(b) The pitot-static system of each aircraft must be checked for freedom from significant leaks before release.
NOTE: The static system may leak at 100 feet/min. With the pitot system pressurised to 85 Knots there must be no change in airspeed over 10 seconds.

(c) The static pressure source must be:
   (1) A single source located on, or close to, the centreline of the aircraft; or
   (2) A dual source, one on each side of the aircraft, connected by a balance tube; or
   (3) A single source that is not located on, or close to, the centreline of the aircraft, provided the error caused by sideslip to the left and right with full rudder deflection in the approach configuration is less than 5 knots.

UA25.1325 Static Pressure Systems

(a) Pitot-static systems will either:
   (1) Be provided with drains which close automatically at their lowest points; or
   (2) Be constructed of a clear material such that moisture or foreign matter may be seen at the lowest points in the lines.

(b) Pitot-static tubing must be supported against chafing, vibration and excessive distortion.

(c) If altitude encoding equipment is to be fitted, then the accuracy requirements and re-calibration requirements of this equipment must be met.
NOTE: Care should be exercised in using unreinforced clear plastic or rubber as the sides may kink and affect the pressure reading. Tubing materials must be corrosion resistant.

UA25.1327 Magnetic Direction Sensor.

Each magnetic sensor when installed may not have a deviation in level flight greater than 2 degrees. This includes the effect of steady electrical loads and radio magnetic interference from on board systems.

UA25.1329 Flight control system

(a) Except for a UAV which is designed to be operated solely within line of sight, a flight control system fitted to an unmanned aeroplane must be programmable and capable of the following types of operation:
    (1) autonomous following a programmed flight plan
    (2) manual responding to input from a controller in a ground station
    (3) reversionary responding to failure of a primary control link
(b) A flight control system operating in the autonomous mode must revert to manual operation on command from the ground control station
(c) An unmanned aeroplane must respond to operator input in a timely manner
(d) An unmanned aeroplane must be controllable in and must be able to maintain:
    (1) heading,
    (2) altitude and
    (3) airspeed

UA25.1351 Electrical Systems – General

(a) The adequacy of electrical power sources must be demonstrated by electrical load analysis or electrical measurement test.
(b) Electrical systems must be free of hazards in themselves and protected from fuel, oil, mechanical damage and water, and from the effects of electromagnetic interference.
(c) Electrical sources must function when connected in combination or independently except alternators, which may need a battery for initial excitation.
(d) No failure or malfunction of any source may impair the ability of any remaining source required in accordance with paragraph UA25. 1309 to supply load circuits essential for safe operation.
(e) There must be a means to indicate to the operator in the control station that electrical supply is adequate.
(f) Electrical components mounted directly to the non-fire side of a firewall must operate safely in the event of an engine fire.
(g) In event of a complete loss of the primary power generating system, the battery must be capable of providing at least 30 minutes of electrical power to those loads that are essential to continued safe flight and recovery.

UA25.1353 Storage Battery Installation

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 operation, may accumulate in hazardous quantities within the aeroplane.
No corrosive fluids or gases that may escape from the battery may damage surrounding structures or adjacent equipment.

UA25.1365 Electric Cables And Equipment

Each electric connecting cable must be a suitable type of adequate capacity and correctly routed, attached and connected so as to minimise the probability of short circuits and fire hazard.
Overload protection must be provided for each item of electrical equipment. No protective device may protect more than one circuit essential to flight safety.

UA25.1385 External Lights

If external lights are installed they must comply with the applicable paragraphs of sections 23.1385 to 23.1401 of FAR Part 23.
NOTE: Operational requirements for external lighting are set out in CAR (1988) 196.

UA25.1411 Flight Termination System

(a) An unmanned aeroplane, unless exempted by CASA, must be fitted with a system which will terminate the flight of the aeroplane either:
  (1) automatically in predetermined circumstances
  (2) manually on command of the operator in the ground control station.
(b) A flight termination system shall be safeguarded from interference leading to inadvertent operation;
(c) A flight termination system shall be safeguarded from unauthorised operation.

UA25.1431 Airborne Radio And Radio Navigation Equipment

(a) Each item of airborne radio and radio navigation equipment must comply with the following:
  (1) The equipment must be suitable for its intended purpose
  (2) The equipment and its aerials may neither in themselves nor by their mode of operation or by their effect on the operating characteristics of the aeroplane and its equipment, constitute a hazard to safe operation
  (3) The equipment must be protected from the effects of electromagnetic interference.
(b) The equipment control and monitoring devices must be arranged in the ground control station so as to be easily controllable by the operator.

UA25.1432 Control Communication Systems

(a) A control communications system (CCS) must allow continuous rapid transfer of data to and from the unmanned aircraft;
(b) the operation of the system must be such that delay in aircraft response to operator input does not exceed five seconds;
(c) A CCS shall be safeguarded from interference;
(d) means shall be provided for monitoring datalink strength.

UA25.1459 Flight recorders.

(a) The ground control station must be equipped with a device to continuously record all aircraft communications and all sensor indication available to the operator in the control station.
(b) The recording device must record must retain data from at least the last 30 minutes of operation.

UA25.1471 Ground Control Station

(a) the ground control station (GCS) must provide a visual presentation of:
    (1) the aircraft flight path; and
    (2) deviation from required ground track
(b) The GCS must be equipped with:
    (1) a means of providing all control input necessary for the safe operation of the aircraft and its ancillary systems;
    (2) warning devices to rapidly alert the operator to system failure;
    (3) communications systems which allow continuous two way communication with ATC and potential conflicting air traffic;
    (4) recording equipment in accordance with UA25.1459;
    (5) a means of activating the flight termination system in accordance with UA25.1411.
    (6) reversionary mode of control in event of failure of autonomous control;
(c) design of the GCS must allow rapid operator response to ATC instructions;
(d) all sensor information mus be displayed in a logical and easily interpreted manner;
(e) there must be a means of testing reversionary modes and FTS systems before flight.

SUBPART G OPERATING LIMITATIONS AND INFORMATION

UA25.1501 Operating Limitations.

(a) Operating limitations 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 operator in the ground control station.
(c) Where limitations have been determined in accordance with sub-paragraph (a), automatic limiting systems may be incorporated in a flight control system in lieu of providing information in accordance with sub-paragraph (b).

UA25.1525 Kinds of Operations.

The kinds of operations (such as VFR, IFR, day, night, or icing) for which the aeroplane is approved and operational restrictions which may be applied are established by demonstrated compliance (or otherwise) with the applicable certification requirements and by the installed equipment.

UA25.1529 Maintenance Manual

Manuals containing all the information essential for proper operation, maintenance, service and adjustments of the UAV system must be provided.

UA25.1531 Operating Manual.

(a) The operating manual which must be available to the operator in the ground control station must include the following information:
   (1) operating limitations
   (2) power plant limitations
   (3) normal and emergency operating procedures
   (4) performance information
   (5) loading information.

Control station

UA25.1541 Information Display.

(a) Operational information critical to the safe conduct of the flight must be displayed to the operator in the ground control station in a manner that is:
   (1) continuously displayed
   (2) easily interpreted by the operator
   (3) not subject to mis-identification.

UA25.1543 Parameters.

(a) Minimum parameters to be displayed are:
   (1) airspeed
   (2) altitude
   (3) direction (heading)
   (4) power setting
   (5) fuel quantity
   (6) battery charge level

UA25.1545 Units of Measurement.

(a) Units of measurement in use shall be:
   (1) airspeed - knots IAS
   (2) altitude - feet
   (3) direction - degrees magnetic

APPENDIX A STRUCTURAL TESTING PROCEDURES

UA25.A1 Test Witness

(a) All structural testing must be witnessed by a person who is independent from the aeroplane design, production and financial aspects of its manufacture. This does not preclude a witness for being paid for his/her work.
(b) Testing of aeroplanes must be witnessed by a person acceptable to the Civil Aviation Safety Authority.

NOTE: Testing aeroplanes should be conducted by an appropriate person. Persons who may be accepted by CASA as a witness for structural tests are CAR35 authorised persons (holding structural authorisations), an aeronautical, civil or mechanical engineer who is a full member of the Institution of Engineers Australia or a Licensed Aircraft Maintenance Engineer who holds a fixed wing airframe license.

UA25.A2 Conformity

It is the responsibility of the test witness to ensure that:

(a) Two sets of drawings be supplied for each item to be tested and that these drawings adequately depict the structure.
(b) The article to be tested conforms with the drawings.

NOTE: Minor variations from the drawings are allowed provided that the test item is not stronger or stiffer than the production item. Variations must be sketched directly onto each set of drawings.

(c) The test witness may delegate the conformity inspection responsibility.
(d) For structure types that become uninspectable once construction is complete, either stage conformity inspections or witnessing of manufacture must be conducted.
(e) Once the conformity inspection is complete, the inspector must sign and date both sets of drawings retaining one set for his own records and returning one set to the manufacturer. The persons name, qualifications and contact address must be clearly printed beside their signature.

UA25.A3 Test Schedule

The aircraft designer must prepare a written, detailed test schedule prior to the test. The test schedule is usually required to be accepted prior to conducting the test and may also be used to record test results. The test schedule must include:

(a) The design requirement being demonstrated by the test, the applied load and position of this load at each station.
(b) Deflections to be measured during the test.

NOTE: Deflections will normally be required to be measured during limit load tests. These measurements will normally be vertical deflections and angular rotations at wing and control surface tips.

(c) Other tests to be made during the test, such as movement of control surfaces or pressurisation of integral tanks.

NOTE: Recording some test results are best handled by placing YES or NO type questions in the test schedule.

(d) The witness is only responsible for ensuring that the tests listed are carried out and that recorded results are correct. The contents of the test schedule are the responsibility of the applicant for type certification. If at a later date the test schedule is found to be incomplete, non-conservative or inaccurate then further tests may be required, particularly if only limit load testing is conducted.

UA25.A4 Accuracy

The witness must ensure that test loads are accurate. Scales used to weigh test weights must be calibrated just before use. This may be done by using known weight or by calibrating against scales that have themselves been calibrated. In performing calibration of scales just before testing, the calibrating loads must be applied at least twice and recorded loads must be within 2% of each other.

NOTE: Commercial bathroom type scales have been used in the past and found quite satisfactory provided a stiff piece of plywood is placed on top of the scales so that the weight is applied to the whole of the platform. Test weights should be dry and relatively free of loose dust and dirt.

UA25.A5 Preload

Most structures demonstrate non-linearity on initial loading, it is therefore recommended that prior to conducting limit load testing a pre-load of 50% of limit load be applied and removed before starting limit load testing. Even so, it is probable that some non-linearity will be observed, whether this is true yielding and permanent set or simply settling of the structure under load will be a matter for judgement by the witness.

UA25.A6 Loading

If loose loading using sand bags or bricks is applied then the loads applied at each station must not significantly interlock with loads placed at adjacent stations.

UA25.A7 Temperature Conditioning - Composite Flight Primary Structures

(a) Prior to testing, production curing procedures must be specified for fibre reinforced composite flight primary structures and the test witness, or his/her delegate, must ensure that the production curing procedure has been used for the test article.

(b) Prior to testing, the test structure must be moisture conditioned to a representative state expected in service and heated to the temperature indicated below, depending on the colour of the sun receiving portion of the structure. These temperatures are surface temperatures.

COLOUR	TEST TEMPERATURE ^{O}C
White paint	54
Zinc Oxide	60
Light Green	70
Light Yellow	70
Black or Dark Blue	80

(c) The heat must be supplied for a sufficient length of time to ensure that the interior of the structure is not cooler than the surface temperature by more than 5^0C.

(d) During load application the surface temperature may not cool by more than 10^0C.

NOTE: This means that the structure must be rapidly loaded. An option may be to support the structure, pre-load, then heat and then remove the supports.

UA25.A8 Records

(a) The test record must be filled out, signed and dated by the person performing the test.

NOTE: A copy of the test schedule may form the basis of the test report. See UA25.A3.

(b) The witness may make comments on the test record, as seen fit, and must sign and date the test record. The witness' name and contact address must be printed beside the signature together with qualification details (Refer UA25.A1(c)).

(c) It is recommended that names and addresses of any other persons present are recorded.

(d) It is recommended that photographs of the test are taken and included in the test record.

(e) At least 2 copies of the completed test record must be made, 1 copy being retained by the manufacturer and 1 copy by the witness.

APPENDIX B MATERIALS ACCEPTANCE AND STORAGE

UA25.B1 Scope

This appendix outlines methods of material acceptance and storage suitable for aeroplane manufacture. The objective of such procedures is to demonstrate:

(a) That the material meets the mechanical strength properties selected by the designer.
(b) That any defects remaining in the material after acceptance will only have a very minor impact on aeroplane integrity.
(c) That the material, once accepted, is stored such that it will not deteriorate prior to use in manufacture.

NOTE: The level of acceptance inspection and testing for materials used in aircraft manufacture will depend on what (if any) standards the material has been supplied against, what material properties have been adopted by the designer during analysis and the consequence of failure with regard to flight safety.

UA25.B2 Mechanical Properties For Structural Analysis Purposes

(a) Material supplied against an aircraft standard specification, by a recognised aircraft supplier, and line marked so as to be identified or supplied with a serviceability tag require no testing and material properties used for design may be those listed in MIL-HDBK-5 or other standard source.
(b) Materials supplied against an Australian Standard which incorporates material variations may be used for design. The aluminium code AS 1664 meets this requirement.
(c) For mild steel sheet and cold drawn and welded (CDW) tube, the yield tensile strength may be taken as 250 MPa (36Ksi) and ultimate tensile stress may be taken as 380 MPa (55Ksi). These values must be factored by 0.75 to get design allowables, however no factor need be applied to tubing that fails from column action. It is recommended that CDW tubing is only used where simple truss action prevails, with members critical in compression. In areas of significant tension or bending, such as wing-fuselage carry through members, aircraft grade material, such as 4130 released to an aircraft standard, is recommended.
(d) Where timber is concerned, the designer is free to select the design allowable strength, as each and every piece of timber used in critical flight structure locations must be sample tested for strength. To ensure that the rejection rate is acceptable, the design allowable stress should be kept under the mean failure stress. In the first instance it is suggested that the allowable be not more than 92% of the mean failure stress of representative samples. Note that the test may be either a direct compressive stress or a bending modulus of rupture test. Hoop pine is often used as a substitute for spruce. A conservative procedure is to use spruce allowables when designing with hoop pine, though this may lead to a somewhat heavy structure. In laminating spar caps from solid timber, wood species must not be mixed.

NOTE: Contrary to popular opinion, wooden structures do suffer fatigue failure in both tension and compression, however, as the endurance limit is generally about 2/3 of the modulus of rupture this is not often of concern. Nevertheless, a conservative approach to design of wooden structures is recommended. It is advisable to follow the practices outlined in ANC-18 for joint design. It is also recommended that ultimate beam tensile stresses be limited to 80% of modulus of rupture values.

(e) ANC-18 gives all the data one will require to analyse plywood. Most imported aircraft plywood is birch-birch, however locally performed tests have shown that hoop pine plywood Grade A (all veneers hoop pine) of a balanced design (total thickness of even number plies approximately equal to that of odd number plies) manufactured to AS2272-1979 will have a strength at least equal to that of birch-birch thus ANC-18 data for birch-birch may be used in analysing hoop pine.

(f) As plywood is a very notch sensitive material, all cutouts in tension skins should be reinforced with doublers and it is recommended that the ultimate tensile stress in wing spar lower booms be kept down to 80% of the lower spar boom material modulus of rupture. This particularly applies to spars with discrete flanges and plywood spar webs. Laying the web on a 45 degree bias will eliminate this problem, but this is often not economically practical.

(g) Grade B plywood can be used for skinning and rib webs, etc., provided that the shear stress in these items does not exceed 50% of the ultimate shear stress of the basic material (note we are not concerned with buckling here).

(h) Composite materials are similar to timber in that laid up samples must be taken from highly loaded components such as wing spars and tested to ensure that the flight article has strength available that exceeds values used in the design process. This assumes that in addition to testing, establishment of ultimate load carrying capacity of highly stressed items is performed by calculation.

(i) Suggested design allowable values for E glass in epoxy resin laminates, using a room temperature cure and wet lay up procedure, is 413 MPa (60Ksi) for unidirectional cloth, 275 MPa (40 ksi) for a twill weave bi-directional cloth and 206 MPa (30Ksi) for a plain weave bi-directional cloth. For other fibres, the designer should be guided by fibre manufacturers advice. The designer should, before starting the design process, perform some tests to ensure that design allowables used will be achievable.

UA25.B3 Materials Acceptance

All inwards goods to be used in aircraft construction must be inspected and either accepted into the materials store or rejected and removed from site. The level of inspection to be applied depends on how critical the particular application is, thus it may not be sufficient to simply accept aircraft grade materials that are used in high tension stress non-redundant areas without some form of extra testing and inspection. Thus, inwards acceptance may be part of the type design procedures. Selection of material properties is very much a matter for judgment by the designing engineer. By the time the aircraft structure has been designed, drawn, analysed, constructed and tested there is probably no other person more familiar with the structure than the designing engineer. It is therefore incumbent on the designer, at a very early stage, to write down any inwards acceptance procedures considered necessary in light of all the surrounding circumstances. Some of the factors to be considered are the estimated stresses in the component, inspectability, the notch sensitivity of the material, whether there is redundancy of load paths, the component location and possibility of service damage, the consequences of failure and the material's source and level of material inspection prior to delivery to the aircraft manufacturer's premises.

In the end, materials only fail in service because the applied stress is too high under service conditions, thus it pays to exercise a degree of conservatism. Dealing with various materials, recommended practices are:

(a) Aluminium sheet. Stock that is supplied by a manufacturer with a line mark, or other acceptable identification, to an aircraft standard or to an Australian Standard by a manufacturer who has ISO 9002, will normally only require a visual inspection for good condition. If the sheet is to be used to make the lower spar cap of a wing in a non-redundant, non-inspectable application then a check of mechanical properties and ultimate tensile stress measurement may be required.

(b) Aluminium extrusions. Stock that is supplied with a certification (which may take the form of line marking) by a manufacturer with a recognised quality assurance program in place, such as ISO9002, can generally be accepted without further testing. However, in general, the U.S. MIL standards and the Australian AS standards only require chemical composition and hardness or mechanical properties testing. There are other extruding defects that can occur and, depending on how critical the application is, further inspections may be required. These inspections may include micrographic or ultrasonic inspections or a limit load test of the extrusion. In general further inspections will not be required where there is a degree of structural redundancy and where there is reasonable inspectability or where the principal loading mode is compression.

(c) Steel Tubing. Line marked 4130 steel tubing requires an inwards visual inspection only. Mild steel CDW tube should be visually inspected over its length for integrity of the seam and for general condition. For CDW tube, a short piece (at least 1 tube diameter) should be cut from each end and positioned between the jaws of a vice with the longitudinal weld seam at 45^0 to the vice jaws. The section of tube should then be completely flattened and there should be no cracks or flaws in the flattened tube. Testing the mechanical properties of CDW tube is not necessary if strength values below those stated in UA25.B2 (c) above are used. The tube flattening test may not be necessary if the material is supplied by a company with ISO 9002 certification that will provide a quality assurance for each and every piece or batch of material supplied against an accepted standard that addresses chemical properties, freedom from all reasonable manufacturing defects and manufacturing dimensional tolerances.

(d) Steel Sheet, Plate and Bar Stock. Line marked (or properly identified) sheet, plate and bar stock should at least be visually inspected for acceptance. Additional acceptance criteria should relate to the nature of the intended use. Under no circumstances should free machining steels be used to make aircraft parts. Steel material Bisalloy 80 is acceptable as a substitute for 4130 steel. Bohler VEW K245 steel is suitable for making leaf spring type undercarriages.

Note that all heat treated steel items should be subjected to a hardness test and magnetic particle inspection (MPI) after heat treatment.

(e) Material hardness measurements are a good indicator of ultimate tensile stress for steel components. This is particularly true for low alloy steels in both the normalised and heat treated condition.

(f) Timber. Inspection of timber is a skilled occupation. It is recommended that the services of a local state government forestry technical services officer are used in all matters relating to timber inspection. These officers will inspect the timber, perform either a compression test or modulus of rupture test, as required, and provide a written certification as to the quality of the timber.

(g) Plywood. For highly stressed Grade A plywood ensure that the plywood sheet is marked as meeting AS2272 (Marine grade). Carefully examine the external surfaces and the edges. There should be no butt joins across the veneers and no major defects present anywhere. The airframe manufacturer should contact the plywood manufacturer and arrange for workshop inspection and witnessing of the laminating process (at least in the first instance) to ensure that internal laminates are of the same quality as the external laminates. Grade B plywood needs only an external inspection, with external veneers free of butt joints across the grain direction.

(h) Composite material. Where composite materials are concerned, it is difficult to perform inwards acceptance testing other inspecting for good condition. A record should be available to show that all recommendations of the material manufacturer have been following during shipping and storage. Shelf-life should be sufficient to last until the material is used. Gel-time testing should be performed for vinyl ester resins. In production, it is important to make test coupons with each primary flight structure layup. Where straight out bonding is performed, sample testing of the glue should be performed.

(i) Miscellaneous parts. Commercial monel pop rivets may be used, provided they are visually inspected. Commercial cables, and cable end fittings, should be proof loaded (60% ultimate breaking load) when assembled, including any associated components. For other commercial fasteners used in construction of the aircraft, inwards inspection techniques based on the particular application should be developed. For example, any bolts used in critical applications should have a hardness test performed on one bolt (which is then discarded) and then 100% of the batch should then undergo magnetic particle inspection.

UA25.B4 Storage

Once accepted, materials should be stored in a suitable manner until required for use in manufacture. Items with a shelf-life should be so marked and used via stock rotation to ensure that oldest in-life items are used first.

Accepted materials, if not already marked, must be marked and logged into the store. The log should contain material type and size, place of purchase, acceptance details, date of acceptance and who performed acceptance inspection.

Accepted materials should firstly be segregated by material type and the degree of inwards inspection. Materials should then be racked according to size. Note that in performing the first segregation, it is important to physically separate the storage areas so as to minimise the chance of mix up, thus for example, 4130 tube and mild steel tube should not be held in the same rack.

Care should be taken so that materials are not damaged while stored. All items should be stored in a building, up off the floor. Timber should be racked flat, or clamped flat if stored vertically. Steel sheet and tube should be oiled. All metal sheet and tube should be stood on edge or at least racked on a slope.

Inventories should be checked on a regular basis and once a source of material has been used up, its log card should be archived.

APPENDIX C ENGINES

UA25.C1 Applicability

This appendix details requirements for the design, manufacture and installation of approved installation engines (AIE) in unmanned aeroplanes. This appendix relates to spark and compression ignition engines only.

NOTE: Aeroplanes that use AIE may attract special conditions, subject to overall review.

UA25.C2 Instructions For Continued Airworthiness

Engines must be provided with a maintenance manual. This manual must contain servicing and overhaul data, including a schedule detailing the inspection and overhaul intervals.

NOTE: If an engine is supplied with a servicing and overhaul manual but no schedule, then the airframe manufacturer must prepare a schedule from the data that is available.

UA25.C3 Instructions For Operation

The engine must have a determined set of operating limitations, including speed limitations, cooling limitations, lubricating temperatures and pressures (if a separate lubrication system is provided), fuel pressure range and oil consumption rate for 2 strokes with separate oilers.

UA25.C4 Materials

Engines and components manufactured by the applicant must be constructed of materials controlled by the applicant whose suitability and durability must:

(a) Be established on the basis of experience and test.
(b) Conform to an established specification.

NOTE: Materials with known poor characteristics, such as free machining steels, must not be used.

UA25.C5 Fire Prevention

(a) External lines or fittings that convey flammable fluids must be at least fire resistant. Hoses must be positively retained and where hoses push over nipples they must be retained with a hose clamp and the nipple must have a raised ridge to prevent the hose from coming off once the clamp is tightened.

(b) Components must be shielded or located in positions where leakage of fuel is unlikely to cause a fire.

NOTE: This applies particularly to fuel and electrical components and where the exhaust manifold exceeds the auto ignition temperature (refer: UA25.1121(b)). The effect of fuel pump diaphragm failure and carburettor flooding must be considered.

(c) Inlet manifolds must be arranged such that pooling of fuel within the inlet manifold cannot occur.

NOTE: Fuel in the inlet manifold may drain out through the engine or it may drain back out through the manifold.

UA25.C6 Engine Cooling

(a) Engine design and construction must provide the necessary cooling under conditions in which the aeroplane is expected to operate.

NOTE: In the absence of manufacturers data, determination of allowable temperatures may be performed by comparison with other engines that are known to have satisfactory performance. The following locations should be considered, cylinder head, cylinder barrel (if air cooled), coolant temperature, oil temperature, gearbox temperature, ignition system cooling, generator or alternator cooling. Compliance with this clause is not necessary if the engine has an established history of satisfactory operation.

(b) In conducting the endurance test detailed in UA25.C12, at least 25 hours must conducted with the engine operating at highest allowable temperatures.

NOTE: This means that at least one cylinder must be at the highest cylinder head temperature or coolant must be at highest allowable temperature. Oil must also be at highest temperature (if there is a separate oil system).

UA25.C7 Vibration

Engines must be mounted on shock absorbing mounts which minimise the transmission of vibration to the airframe.

UA25.C8 Output Shaft

(a) Engine output shafts must be analysed for the following four loads acting together on the output shaft. They are:
  (1) Maximum thrust.
  (2) Maximum Torque factored as per UA25.361(b).

(3) Gyroscopic moments based on the highest likely propeller rotational inertia together with a pitching or yawing angular velocity of 1 radian/second.
(4) Inertia loads detailed in UA25.337.

(b) Local stress raisers must be considered in determining stress and this stress must be below the endurance limit.

NOTE: The stress raiser effect may be determined from literature on stress concentration factors and reasonable lateral interpolation of this data is permitted. For steel shafting, the endurance limit may be taken as 45% of ultimate tensile stress but not greater than 310MPa (45Ksi). Torque factoring under UA25.361(b) may be reduced if experimental determination of maximum torque impulses has been undertaken.

(c) This analysis is not required for engines which have demonstrated a history of safe operation in this area.

UA25.C9 Lubrication System

Where engines have a separate lubrication system, this system must:

(a) Provide adequate lubrication with the engine pitched 30^{o} nose down and nose up and banked sideslips 30^{o} left and right with the oil tank half full.
(b) Be designed and constructed to allow installing a means of cooling the lubricant where the lubricant is heated.
(c) have a vented crankcase, or prevent pressure building to a point where crankcase leakage might occur.

UA25.C10 Vibration Test

Engines must undergo a torsional vibration test from idling rotational speed to 110% maximum continuous rotational speed or 103% maximum take-off rotational speed, whichever is the greater. Hazardous conditions must not be present.

NOTE: This test is not necessary if either the engine is known to have a history of safe operation from a vibration point of view, or if a torsional damper of known dynamic spring constant is provided and the first torsional resonance frequency is set at least 200 RPM - crankshaft under the idling RPM. In measuring torsional vibrations a shear strain gauge must be placed on the engine output shaft.

UA25.C11 Detonation Test

Spark ignition engines must be tested to establish that they can be operated throughout the intended speed range without detonation.

NOTE: Engines may be accepted on the basis of a history of safe operation, noting that if a fixed carburettor jet size is used then this size must be specified. Detonation may be confirmed in extreme cases by a sharp increase in exhaust gas temperature.

In testing engines for detonation, the inlet air must be varied up to a maximum of 38^0 (100^0), the fuel grade must be of the lowest octane rating that is to be used and jet sizes must be to the tolerance that produces the leanest mixture.

Detonation may be found by rigidly attaching a suitable pickup (dynamic microphone) to the cylinder head, and is indicated by sharp spikes in microphone response generally occurring within 5-10 degrees after spark ignition with a characteristic frequency approximated by:

$F = 900/\pi R$ Hz
where R is the cylinder radius in metres.

UA25.C12 Endurance Test

(a) A representative engine must be subjected to a 50 hour bench endurance test consisting of twenty five repetitions of a 2 hour test cycle. Each test cycle must be conducted as shown in the table below.

Sequence Number	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	max continuous power
9	5	Cooling run (idle)
10	60	Maximum continuous power
11	5	Cooling run and stop
TOTAL	120	

(b) Additional endurance testing may be required depending on the results of the above test.

NOTE: If major alterations or repairs are required to improve reliability, testing must re-start at the beginning.

(c) For the endurance test a representative propeller of sufficiently low pitch to allow take-off power RPM to be achieved must be used.

NOTE: "Representative" means a propeller whose rotational inertia will be similar to the propeller that is to be used in service.

(d) Fuel and oil consumption must be measured during the endurance test.
(e) After the endurance test the engine must be completely disassembled. No essential component may show rupture, cracks or excessive wear.
(f) The engine need not be subjected to an endurance test provided a history of safe operation can be demonstrated.

APPENDIX D PROPELLERS

UA25.D1 Applicability

This appendix details requirements for the design, manufacture and installation of propellers acceptable for use on unmanned aeroplanes.

UA25.D2 Instruction Manual

A manual detailing installation, servicing and maintenance instructions for the propeller shall be prepared.

UA25.D3 Propeller Operating Limitations

Propeller operating limitations, including the maximum rotation speed (RPM), maximum and minimum diameter, pitch limits and balance requirements, as applicable, must be specified.

UA25.D4 Propeller Materials

Propellers must be constructed of materials whose suitability and durability:

(a) Have been established on the basis of experience or test; and
(b) Conform to an established specification.

NOTE: Adequate finishing and protection against weathering and corrosion must be specified.

UA25.D5 Pitch Control

(a) Variable pitch propellers must be fitted with fine pitch stops or a safety mechanism such that failure of the propeller pitch control will not cause hazardous overspeeding.

(b) Ground adjustable propellers must have a means to accurately set and lock blades.

UA25.D6 Propeller Stress Analysis

(a) Propellers must have a static stress analysis which considers the following cases:
    (1) Rated RPM, maximum thrust and maximum torque; and
    (2) Rated RPM and zero thrust and zero torque.
(b) In performing this stress analysis, the following assumptions may be made:

(1) Blade sections are folded flat onto the propeller disc and that thrust acts normal to the disc.
(2) Blades (with exception to the blade root) need only be analysed for thrust and centrifugal load effects.
(3) At the blade root, the blades must be analysed for thrust, torque (from the propeller drive shaft), centrifugal loads and pitch change masses if they are installed.
(4) The spanwise thrust load distribution may be taken as shown in the diagram below.
(5) For wooden propeller blades, the limit tensile stress must not exceed 28 MPa (4Ksi) and the limit compressive stress must not exceed 17 MPa (2.5Ksi).
(6) For metallic and composite blades, hubs and pitch change components tensile stresses must not exceed the endurance limit. Stress concentration factors must be considered. For composite propellers, fibre orientation must be considered.

NOTE: The endurance limit for metals may be taken as 45% of the ultimate tensile stress except that it may not exceed 310 MPa (45Ksi) in steel and 186 MPa (27Ksi) in aluminium. The endurance limit may be exceeded where it can be clearly shown that pre-tensioning is such that there is no variation in stress in normal operation.

(7) For wooden propellers, the attach bolt pattern must be arranged for maximum through grain wood. In analysing the hub, only through grain wood may be considered as load carrying.
(8) For wooden propellers, power must be transferred from the drive shaft to the propeller via friction with the hub face only.

UA25.D7 Blade Retention Test

The hub and blade retention arrangement for propellers with detachable blades and wooden propellers where through grain wood does not pass through the hub such as 3 bladed propellers must be shown by test to be capable of sustaining an ultimate load equal to twice the centrifugal force occurring at maximum rotational speed (other than transient overspeed) for which approval is sought. This may be done either by a whirl test (at reduced pitch if desired) or a static pull test.

UA25.D8 Endurance Test

(a) Propellers with metallic or composite components must be subjected to the test specified in UA25.907(c)(2).
(b) For fixed pitch wooden propellers an endurance test of 50 hours is required. At least 5 hours must be at the rotational speed and power associated with maximum climb and the remainder of the 50 hours at a rotational speed not less than 90% of the speed associated with the aforementioned maximum climb condition.

UA25.D9 Pitch Change Endurance Test

For propellers whose blade pitch may be varied in flight, the following test must be undertaken after the test specified in UA25.D8(a) has been completed. For this test the propeller is to be operated at the maximum R.P.M. with the propeller in fine pitch and the disc 20^0 block out is not required. The tests to be performed are:

(a) 1500 complete cycles throughout the available pitch range, excluding the feathering range.
(b) A tear down inspection of the test article must be conducted, following the pitch change endurance test. The pitch change mechanism may not show any rupture, fatigue or appreciable wear.

NOTE: Propellers that have been used to demonstrate compliance with UA25.D8(a) and UA25.D09 may not subsequently be used as flight propellers.

UA25.D10 Propeller Adjustment And Parts Replacement

Servicing and minor repairs may be carried out whilst performing the tests specified in UA25.D8 and UA25.D9. However any change which significantly affects endurance will require the recommencement of testing at the start. Note that after testing is over, changes that will improve endurance may be made without re-testing.

UA25.D11 Marking

(a) Each propeller must be permanently marked with:
   (1) The type number or drawing number.
   (2) The maximum rotational R.P.M.
   (3) For fixed pitch wooden propellers, the maximum and minimum diameter.
   (4) For fixed pitch propellers, the pitch.
   (5) For variable pitch blades, the maximum and minimum pitch limits.

   NOTE: Pitch limits may be lines, centre pop marks or paint lines on the hub and blade. Care must be taken to ensure that marking is performed and located in such a way as to not produce significant additional stress raisers. Pitch is defined as forward movement that the propeller would make without slippage based on the flat rear surface of the propeller at the 75% radius point.

(b) If the blades may be removed from the hub, both hub and blades must be clearly marked to ensure that the requirements of the installation manual can be maintained.

   NOTE: The intention here is to retain compatibility between blade and hub types.

APPENDIX E DOCUMENTATION

UA25.E1 General

(a) It is recommended that the Civil Aviation Safety Authority, or an approved organisation, be supplied with a copy of the design data listed in this appendix if the aeroplane (including its ground control system (GCS)), engine or propeller is type certified.
(b) Type design data is confidential and held in trust by the body holding this data. It is recommended that an authorisation be provided to release type design data after a period of 10 years after ceasing commercial activity relating to production or support of the aeroplane. The authorisation should be renewed if there is a change of type certificate holder.
(c) All data for type certification will be required by CASA to be in the English language.

UA25.E2 Design Data - Type Certification

The required design data for type certification is:
(a) For the certification of an aeroplane, a compliance statement against this document. This includes a compliance statement against Appendices C and D of this document, if required.
(b) A draft type data sheet.
(c) A consolidated list of all drawings, reports, manuals and data that describe and substantiate the type design.
(d) A flight type inspection report. A ground type inspection report may also be required if not included in the flight type inspection report.
(e) Structural substantiation and test reports, as required.
(f) A copy of all drawings, which must include:
    (1) A general arrangements drawing giving key overall dimensions, engine type, propeller type, control surface movements, airspeed limitations, CG datum and loading data, aircraft manoeuvre load.
    (2) Assembly drawings for the structure of the aircraft.
    (3) Detailed component drawings, as required, for the aircraft structure.
    (4) Detailed drawings showing all pitot and static pressure port installations.
    (5) Schematic drawings showing approximate routing positions of aircraft systems.
(g) A flight manual.
(h) A maintenance manual.
(i) A parts manual.

NOTE: For smaller aircraft of simple design, provision of copies of assembly drawings and system schematic drawings should suffice.

UA25.E2 Design Data - GCS Certification

The required design data for GCS certification is:

(a) A compliance statement against this document.
(b) A system operational performance report.
(c) A copy of all drawings, which must include a general arrangements drawing giving key location of required components and controls.
(d) An operating manual.
(e) A maintenance manual.
(f) A parts manual.

Note: A UAV system comprises both the air vehicle and the GCS. While each may be certificated independently, normal procedure would be to assess the integrated UAV system unless it can be shown that individual elements of a UAV system are interoperable with other UAV systems. GCS compliance would then be assessed against air vehicles of the type to be operated by the GCS.