AUSTRALIAN SPORT ROTORCRAFT ASSOCIATION INC.

ABN: 53 412 417 012

ASRA BASIC ULTRALIGHT GYROPLANE CONSTRUCTION STANDARDS

Table of Contents

VERSION CONTROL TABLE

VERSION NUMBER	PUBLISHED DATE	AUTHOR	REVISION NOTES
Version 1.0	28/12/2024	M.Robertson	Initial version for Part 149

INTRODUCTION

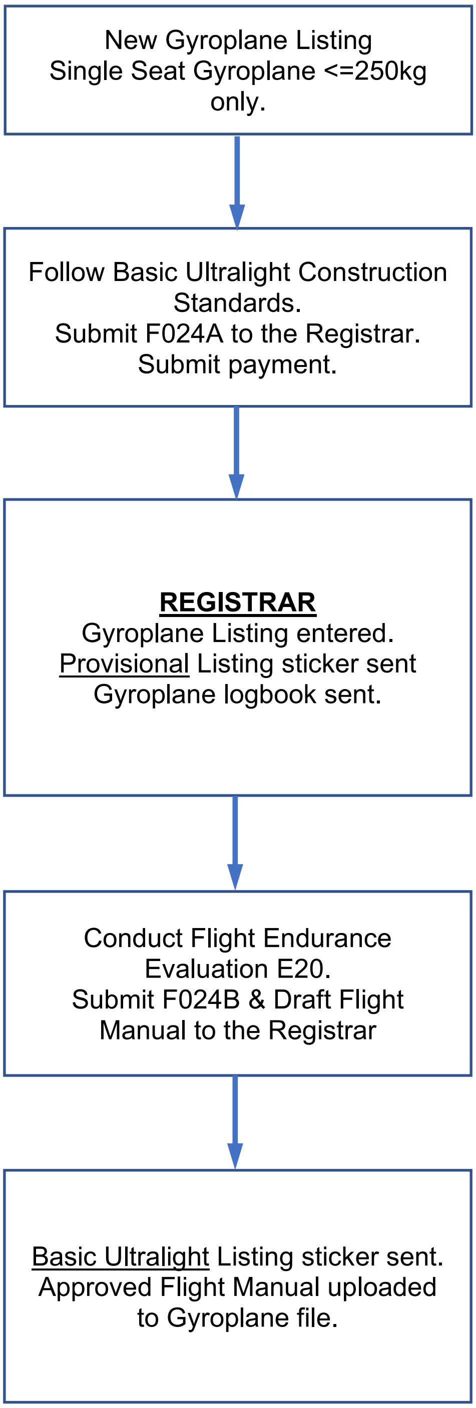
Neither CASA nor ASRA guarantee the airworthiness of any gyroplane, and pilots fly gyroplanes at entirely their own risk.

The Construction Standards must therefore be seen as solely a pre-requisite for listing and not to be considered as any information to which any form of liability attaches.

Table of Contents

NEW GYROPLANE LISTING PROCEDURE.

The flow chart below represents the steps to follow to obtain final Basic Ultralight listing.



ABBREVIATIONS AND DEFINITIONS

Factor of safety	Multiplier of limit load to determine design ultimate load.
Fireproof	Capable of withstanding for a period of at least 15 minutes the application of heat by the standard flame.
Fire resistant	Capable of withstanding for a period of at least 5 minutes of heat by standard flame.
Standard flame	A flame with the characteristics which are similar to those described in BS3G.100-part 2 Section 3013.
Limit load	Maximum expected static load on a component.
Primary structure	Those parts of the structure the failure of which would endanger the gyroplane.
Power off	For evaluation purposes means engine at idle.
Cockpit	The position from which the pilot controls the gyroplane, whether it is enclosed of not.
Ultimate load	Limit load multiplied by the factor of safety.

<u>Acronyms</u>

C of G	Centre of gravity
EAS	Equivalent air speed.
IAS	Indicated air speed.
PSIG	Pounds per Square Inch Gauge
RPM	Revolutions Per Minute
VD	The Maximum Design Speed, EAS.
VDF	The Maximum Demonstrated Flight Speed. EAS.
VNE	The Never Exceed Speed, IAS.
VY	Best Rate of Climb Speed, IAS.
VMIN	Minimum Level Flight Speed, IAS.
VH	Maximum speed in level flight with the engine at maximum continuous power, IAS.
g	The acceleration due to gravity is 9.80 ms^{-2}

SUBPART A - General

A5 Purpose

These Construction Requirements (hereinafter referred to as the "Requirements") have been submitted to the Civil Aviation Safety Authority (CASA) to enable the Australian Sport Rotorcraft Association (ACT) Inc. (ASRA) to list a gyroplane for operation as a Basic Ultralight Gyroplane under the authority granted by CAO 95.12 and, when gazetted, CASR parts 103 and 149.

A10 Applicability

(a) These requirements shall be applicable to gyroplanes conforming to the requirements of CAO 95.12 namely: -
- (i) A single seat; and
- (ii) An empty weight not exceeding 250 kg, and
- (iii) A maximum take-off weight not exceeding 600 kg.

When CASR part 103 is gazetted CAO 95.12 will be discontinued and these requirements shall be applicable to gyroplanes conforming to the requirements of CASR part 103 namely: -
- (i) it has 1 seat; and
- (ii) it has only 1 engine and only 1 propeller; and
- (iii) its rotor disc loading is no more than 20 kilogram per square meter; and
- (iv) its MTOW is no more than 600 kilograms; or
- (v) if it’s equipped to land on water 650 kilogram.

(b) A gyroplane is defined as a rotorcraft with rotor blades that are not engine driven in flight and is supported in flight by the reaction of the air on one of more rotors which rotate freely on substantially vertical axes, when the aircraft is in horizontal flight.

(c) These requirements apply to gyroplanes of orthodox design. Aircraft having the following features will be so regarded: -
- (i) A single non-power-driven teetering rotor, of either fixed pitch or pitch control that is not adjustable in flight.
- (ii) A conventional 'offset gimbal' rotor head, through which varying flight loads are transmitted to the control column.
- (iii) Where the horizontal stabiliser incorporates control surfaces, these are not to be adjustable in flight.

(d) Where it can be shown that a particular feature is similar in all significant respects to a feature which has historically demonstrated compliance with these requirements and can be considered a separate entity in terms of its operation, that feature shall be deemed to be applicable and in compliance with these requirements.

(e) Where a particular feature is not similar to one which is part of a previously accepted design, the feature may be proved during the Gyroplane Flight Endurance Evaluation.

(f) Permitted Operations.

These requirements apply to gyroplanes designed for non-aerobatic operation, including: -
- (i) Any manoeuvre necessary for normal flying.
- (ii) Steep turns in which the angle of bank does not exceed 60 degrees.
- (iii) Vertical descents

SUBPART B – Flight

GENERAL

B10 Load Distribution Limits

The recommended balance or hang test range is between 9- and 12-degrees nose down, measured on the horizontal datum line, when the gyroplane is suspended from the teeter bolt, with the pilot in the seat, with half the maximum fuel and with the control column in the neutral position. This hang test range must be recorded in the Flight Manual. Refer to appendix 1.

B15 Maximum Weight of Basic Ultralight Gyroplanes

The maximum weight must be established where-by the gyroplane will balance within the desired range. This weight limit must be recorded in the Flight Manual.

B20 Empty Weight

The empty weight must be established where-by the gyroplane will balance within the desired range. This weight limit must be recorded in the Flight Manual.

B30 Tilt Back Test

To precisely find out the relationship between vertical centre of gravity and propeller thrust line for each individual gyroplane, with the result that individual owners (and ASRA) will become aware that the particular gyroplane is, or gyroplanes are, either LTL, CLT, or HTL. Refer to appendix 1 for proper procedure.

PERFORMANCE

B35 General

The performance prescribed in this Subpart B must be determined

(a) With normal piloting skill under average conditions.
(b) In still air at sea-level corrected for ICAO defined standard atmosphere.
(c) At the most critical weight; and centre of gravity combination.
(d) Using engine power not in excess of the maximum declared for the engine type, and without exceeding power-plant and propeller limitations established under G20

B40 Take-off Distance

The distance(s) required from rest, to take-off and climb to 50 ft above the take-off surface, with zero wind, must be determined using normally accepted flight technique(s) (with and without pre-rotator if it is determined that the Gyroplane is to be operated both ways).
These established take-off distances must be recorded in the Flight Manual.

B45 Climb Rate

The time for climb from leaving the ground up to 1000 ft above the field must be determined and when corrected to the international standard day conditions at sea-level, must not exceed four minutes with not more than take-off power and without exceeding temperature limits established under E110 (See nomograph in the appendices).
The established climb rate must be recorded in the Flight Manual.

B50 Minimum Sink Rate

The minimum achievable power off rate of descent (ft per minute) and the associated airspeed (knots) must be established by evaluation at the maximum gross weight with the gyroplane trimmed at the minimum rate of descent airspeed. The minimum sink rate and required airspeed must be recorded in the Flight Manual.

B52 Best Glide Ratio

The best glide ratio is calculated by comparing the height lost (ft) to the maximum glide distance flown (ft). The power off rate of descent and the associated airspeed must be established by evaluation at the maximum gross weight with the gyroplane trimmed to achieve maximum distance flown. The best glide ratio and required airspeed must be recorded in the Flight Manual.

Calculate as follows.

e.g. only.

(a) Sink rate to achieve maximum distance flown = 1250 ft/min.
(b) Speed to achieve maximum distance flown = 62 nm/hr = 62/60 nm/min = 1.03 x 6076 = 6258.28 ft/min.
(c) Best Glide ratio = (b)/(a) = 6258.28/1250 = 5.0:1

B55 Never Exceed Airspeed (VNE)

The maximum safe operating airspeed, considering the controllability, manoeuvrability, and requirements of B85 and B100 to B115, must be established. This airspeed must be established for the worst-case power condition between idle and full power.
The never-exceed speed, VNE, must not exceed 0.90 times the maximum speed demonstrated in flight evaluations (VDF)
The established VNE must be recorded in the Flight Manual.

B60 Minimum Controllable Speed for Level Flight (VMIN)

The minimum speed for level flight at maximum take-off power must be established.
The established VMIN must be recorded in the Flight Manual.

B65 Best Rate of Climb Airspeed (VY)

The airspeed at which the maximum rate of climb is achieved must be established.
The established VY must be recorded in the Flight Manual.

B70 Landing Distance

The distance required to land and come to rest from a point 50 ft above the landing surface, with zero wind, must be determined. An approach speed must be specified.
The landing distances and associated approach speeds must be recorded in the Flight Manual.

B75 Maximum Operating Altitude

The maximum safe operating altitude considering the controllability, manoeuvrability, and stability requirements B85 and B100 to B115, must be established up to an altitude selected by the applicant.
The maximum operating altitude must be recorded in the Flight Manual.

B80 Height/Velocity Envelope

The combinations of height and forward airspeed from which a safe landing cannot be made following engine failure must be established as a limiting height-speed envelope (graph).
The height-speed envelope graph must be recorded in the Flight Manual.

CONTROLLABILITY AND MANOEUVRABILITY

B85 General

(a) The gyroplane must be safely controllable and manoeuvrable with sufficient margin of control movement and blade freedom to correct for atmospheric turbulence and to permit control of the attitude of the gyroplane, at all power settings, at the critical weight and balance, at sea-level and at the maximum altitude. at which the gyroplane will be operated under any conditions probable to be encountered.

(b) It must be possible to maintain any required flight condition and make a smooth transition from one flight condition to another (including turns and slips) without exceptional piloting skill, alertness or strength, and without danger of exceeding the limit manoeuvring load factor, under any operating condition probable for the type, with the engine operating at all possible associated power settings within the allowable range, including the effect of power changes and sudden engine failure. Modest variations from any recommended techniques must not cause unsafe flight conditions.

B90 Longitudinal Lateral and Directional

(a) It must be possible at any speed below 1.3 VMIN to lower the nose so that a speed equal to 1.3 VMIN can be reached promptly.

(b) It must be possible to raise the nose at VNE at all permitted weight limitations and engine powers.

(c) A maximum wind speed, maximum cross wind and maximum tailwind must be established in which the gyroplane can be operated without loss of control near the ground in any manoeuvre appropriate to the type (such as cross wind take-offs and landings), with: -

   (i) Critical weight; and

   (ii) Critical centre of gravity.

These wind velocities must be specified in the Flight Manual.

B95 Pitch Control Force

The pitch control forces during turns or when recovering from manoeuvres must be such that at constant speed an increase in load factor is associated with an increase in control force.

STABILITY

B100 General

(a) The gyroplane must be able to be flown without undue piloting skill, alertness or strength in any normal manoeuvre for a period of time as long as that expected in normal operation.

(b) There must be no tendency for the gyroplane to rapidly increase the turn rate, stick fixed, during a turn with normal accelerations of up to 1.5g at all allowable power settings.

(c) The gyroplane shall not exhibit any serious tendency to enter a Pilot Induced Oscillation (PIO) at all power settings at the critical weight and centre of gravity, at sea-level and at the maximum altitude specified in B75 above.

B105 Longitudinal Stability

The longitudinal control must be designed so that with constant engine power a rearward movement of the control is necessary to obtain a speed equal to or less than the trim speed, and a forward movement of the control is necessary to obtain a speed equal to or greater than the trim speed

B110 Lateral and Directional Stability

a) Following an initial yaw disturbance, with the yaw controls fixed or free and other controls held fixed, the gyroplane should tend to correct automatically for disturbance in yaw within three cycles.

(b) The directional and lateral stability should be sufficient to prevent dangerous flight conditions following abrupt pedal displacements.

GROUND HANDLING CHARACTERISTICS

B120 Directional Stability and Control

The gyroplane must have satisfactory ground handling characteristics, including freedom from uncontrolled tendencies in any condition expected in operation, particularly in all take-off conditions. Nose wheel steering must be so arranged that pushing forward on the right pedal causes the gyroplane to steer to the right and pressing forward with the left pedal causes the gyroplane to steer to the left.

B125 Taxiing Condition

(a) The gyroplane must be safely controllable and manoeuvrable when it is taxied over the roughest ground that may reasonably be expected in normal operation. The gyroplane should at least be suitable for operation from surfaces with short grass

(b) The ground speeds up to which it is safe to taxi, take-off and touch down must be established.

(c) The established maximum ground speeds must be recorded in the Flight Manual.

B127 Ground Resonance

The gyroplane must have no dangerous tendency to oscillate on the ground with the rotor turning. This must be shown for all intended combinations of rotor speed and gyroplane forward speed, through spin up, take-off, landing and taxiing

MISCELLANEOUS FLIGHT REQUIREMENTS

B130 Vibration

Each part of the gyroplane must be free from excessive vibration under each appropriate combination of airspeed and engine power in all normal flight and ground operations.

SUBPART C – Structure

GENERAL

C5 Loads

Strength requirements are stated as limit loads (the maximum load to be expected in service) and ultimate loads (limit loads multiplied by factors of safety).

C10 Factor of Safety

The strength of any safety critical part must have a safety factor of 1.5 for the application.

C15 Strength and Deformation

The structure and control systems must be able to support limit loads without permanent deformation. At any load up to limit loads, the deformation must not interfere with safe operation.

FLIGHT LOADS

C30 Limit Manoeuvring Load Factors

The gyroplane must be designed for positive and negative limit manoeuvring load factors of +3.5 and -0.5 respectively, at all forward speeds from zero to the Maximum Design Speed (VDF).

CONTROL SURFACES AND SYSTEM LOADS

C55 Primary Control System

The part of each control system from the pilot's controls to the control stops must be designed to at least: -

(a) Withstand the maximum pilot forces obtainable in normal operation; and
(b) If operational loads may be exceeded through jamming, ground gusts, control inertia, or friction, support without yielding, 0.6 times the limit pilot forces specified in C60.

C56 Control System Design

The primary control system and their attachment points must be designed to be withstand the loads set out below at C60 and also be capable of visual inspection during normal pre-flight checks and regular maintenance.

Pitch and roll control inputs will normally be transmitted to the rotor head by push-pull control rods although ASRA recognizes that some builders will opt to use push-pull control cables. A significant shortcoming with the use of push-pull cables is that the condition of the internal cable cannot be inspected, as is their reported less-precise "feel".

If a builder-to-order or a home-builder elects to use push-pull cables for pitch and roll in their project, the only approved push-pull cables are **Teleflex 60 Series** with 5/16" UNF thread ends or **Teleflex 80 Series** with 3/8" UNF thread ends. Such cables must be fitted strictly in accordance with the manufacturer's directions with particular care taken in relation to bend radii.

Push-Pull cable installations used for rudder control must be **Teleflex 40 Series** push-pull cables with 1/4" UNF thread ends.

Such Teleflex cable installations in build-to-order and home-builds have an operational life of **1000 hours**.

Because of the sealed or sheathed nature of push-pull cables, the visual inspection requirement is waived for: -

(a) sheaths (if fitted) for rudder cable systems; and
(b) push-pull cables running within sheaths fitted as original equipment by a recognized manufacturer; or
(c) Teleflex push-pull cables running within sheaths in builds-to-order or home-builds as specified above.

C60 Limit Pilot Forces

For primary flight controls. The limit pilot forces are as follows: -

(a) For foot controls, 580N (130 pounds force); and

(b) For stick controls, 445N (100 pounds force) fore and aft, and 300N (67 pounds force) laterally.

STABILISING AND CONTROL SURFACES

C75 Control Surface Loads

Each stabilising and control surface, and its supporting structure, (other than the rotor blades) must be designed so that limit loads are not less than 445 N (100 lbs force) per square meter of control surface

GROUND LOADS

C85 Landing Gear - Shock Absorption

(a) The landing gear shall be capable of absorbing the energy which would result from the Gyroplane being dropped at its maximum permitted take-off weight, in a normal landing attitude, from a height at which the main wheels are 300 mm (12 inches.) above the ground when in the normal position for landing and bearing no weight.

(b) In determining the ground loads on nose wheels, the following conditions must be met, assuming that the shock absorbers and tyres are in their static positions: -

- a. For aft acting loads the limit forces at the axle must be: -
  - i. a vertical component of 2.25 times the static load on the wheel; and
  - ii. a drag component of 0.8 times the vertical load.
- b. For forward acting loads the limit forces at the axle must be: -
  - i. a vertical component of 2.25 times the static load on the wheel; and
  - ii. a forward component of 0.4 times the vertical load.
- c. For sideways acting loads the limit forces at the axle must be: -
  - i. a vertical component of 2.25 times the static load on the wheel; and
  - ii. a side component of 0.7 times the vertical load in either direction.

MAIN COMPONENT REQUIREMENTS

C90 Rotor Structure

Each rotor assembly (including the rotor hub and blades) must be designed as prescribed in this section.

(a) The rotor structure must be designed to withstand the critical flight loads prescribed in C30 and C35.

(b) The rotor structure must be designed to withstand loads simulating, for the rotor blades and hub bar, the impact force of each blade against its teetering stops during ground operation.

(c) The rotors and rotor head structure must be designed to withstand the maximum limit torque likely to be transmitted by any rotor spin-up device or rotor brake at all speeds from zero to maximum at which the device is designed to be engaged.

EMERGENCY LANDING CONDITIONS

C100 General

(a) The structure must be designed to give each occupant every reasonable chance of escaping serious injury in an emergency landing incident, when proper use is made of belts and harnesses provided for in the design, in the following conditions: -

(i) The occupant experiences ultimate inertial forces corresponding to the following load factors: -

Direction	Load Factor
Upward	4.5
Forward	9.0
Sideward	3.0
Downward	4.5

(ii) These forces are independent of each other and are relative to the surrounding structure.

(b) The supporting structure must be designed to restrain, under loads up to those specified in C100 (a) each item of mass that could injure an occupant if it came loose in an emergency landing incident.

(c) For a Gyroplane with the engine is mounted behind the occupant's seat, the engine mounting structure must be able to restrain the engine, propeller and any other items supported by the engine mounting structure, when they experience an ultimate inertial force in the forward direction corresponding to a load factor of 10.

C102 Fatigue Strength

Materials known to have poor crack propagation properties shall not be used in any part of the primary structure.

C104 Special Factors of Safety

The factor of safety prescribed in C5 must be increased to the special factors prescribed in this paragraph.

(a) Rotor Components Factor
The rotor head, rotor hub bar, and blade spar structure shall have a factor of safety of 2.0 for centripetal tension loads acting alone under the critical flight loads in accordance with C90.

(b) The supporting structure and the attachment of rotor blade mass balance weights must have a factor of safety in excess of 1.5 when subjected to the combined loads resulting from: -
(i) Accelerations of plus or minus 20g in the flap plane of the rotor,
(ii) Accelerations of plus or minus 20g in the lag plane of the rotor, and
(iii) The centripetal force at the maximum rotor speed.

Compliance may be shown by a history of safe operations.

SUBPART D - Design and Construction General

D10 Materials

Where bolting is used, 'Aircraft' bolts must be used in the main frame and control components. (i.e. cheek and cluster plates and from the 'hands to the rotors'). Aircraft bolts must also be used on any part which has an important bearing on safety.
Materials shall be durable and suitable for the intended use, and design values (strength) must be chosen so that structural deficiency because of material variations is extremely remote as shown by evaluation, analysis, service history, or manufacturer certification.

D20 Locking of Connections

An acceptable means of locking must be provided on all connecting elements in the primary structure and in control and other mechanical systems that are essential to safe operation of the gyroplane.
In particular, self-locking nuts must not be used on any bolt subject to a rotational force in operation unless a positive locking device is used in place of or in addition to the self-locking device.

D30 Inspection

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

D75 Flutter Prevention and Structural Stiffness

Each major part of the gyroplane must be free from flutter and resonance, in both the free and fixed control mode at all airspeed and power conditions at speeds up to VNE.

CONTROL SURFACES AND ROTORS

D80 Drainage

(a) For each rotor blade: -
  (i) There must be a means for venting the internal pressure of the blade,
  (ii) Drainage holes must be provided for the blade, and
  (iii) The blade must be designed to prevent water from becoming trapped in it
(b) Sub-paragraphs (a)(i) and (ii) of this paragraph do not apply to sealed blades capable of withstanding the maximum pressure differentials expected in service.

D85 Control Surfaces Installations (other than rotor blades)

(a) Movable control surfaces must be installed so that there is no interference between any surfaces or their bracings when one surface is held in any position and the others are operated through their full angular movement. This requirement must be met: -
  (i) Under limit load conditions for all control surfaces through their full angular range, and
  (ii) Under limit load on the gyroplane structure other than the control surfaces.
(b) If a ground adjustable stabiliser is used, it must have stops that will limit its range of travel to that allowing safe flight and landing.

D90 Control Surface Hinges

When using only two hinges at the control surface, the safety factor for these hinges must have a safety factor of 2.5.

D95 Mass Balance

(a) The spanwise balance of the rotor blades must be such that excessive out-of-balance vibration is prevented.
(b) The chordwise balance of the blades must be such that the blades cannot be induced to flutter or weave in all flying conditions. The chordwise balance of each blade in a pair must be the same. The aerodynamic centre should be at or very close to the 25% chord.
(c) The supporting structure and the attachment of rotor blade mass balance weights (if used) must have a factor of safety in excess of 1.5.

D100 Rotor Hub Tilt and Teeter Ranges

(a) Nomenclature

The rotor hub assembly of a gyroplane is an assembly that:

(i) incorporates the rotor spindle axis, either as a fixed tube or fixed bolt (or both) or as a rotating spindle.
(ii) is capable of being tilted from side to side and from vertical to the rear (as specified below).
(iii) incorporates the component customarily called the torque tube or torque bar or variations thereof.
(iv) may incorporate fixed components of a pre-rotation mechanism (if fitted); and
(v) may incorporate a rotating bearing block to which side-towers with provision for rotor-teeter are laterally bolted.

The rotor assembly of a gyroplane comprises:

(i) the rotor blades and blade straps; and
(ii) a hub bar and elevated teeter block (if a solid hub-bar is used) OR (alternatively) Magni-style side-plates.

The following terminology must always to be used:

(i) **TILTING** is confined to describing the side-to-side and vertical-to-aft movement of a rotor hub and spindle assembly; and
(ii) **TEETERING** is confined to describing the see-sawing movement of a rotor assembly within a rotor hub assembly.

(b) Hub Tilt Range

ASRA requires that:

(i) the minimum rotor hub fore-and-aft hub tilt range for gyroplanes shall be **16 degrees**, with the forward limit (normally) being **vertical** and the rear limit (normally) being 16 degrees rear of vertical. Additional tilt range forward of vertical up to 4 degrees can be installed at the discretion of the designer to accommodate a stick forward rotor brake (if fitted). While no maximum rotor-hub fore-and-aft tilt limit is specified ASRA requires that the static clearances to other parts of the gyroplane specified elsewhere in these Standards be maintained.
(ii) The minimum rotor hub side-to-side tilt range for gyroplanes shall be **16 degrees** (i.e. 8 degrees left tilt + 8 degrees right tilt. If the designer rigs a bias allowing one side to tilt slightly more than the other, the minimum tilt either side should still be 8 degrees).
(iii) That the ranges stated above at (i) and (ii) are <u>mandatory</u> for gyroplanes constructed within Australia, either as builds-to-order, home-builds, hybrid conversions, or for the restoring or rebuilding of gyroplanes previously manufactured by companies that are no longer in business.
(iv) In the case of gyroplanes manufactured as an identifiable and identical type by a company or companies that are still operating, where it is found that the tilt ranges of an inspected gyroplane are at variance in some respect from those specified above at (i) and (ii), the matter is to be referred to the Head of Flight Operations (HOFO). Unless otherwise approved by the Head of Flight Operations (HOFO), where there are existing minor non-compliance issues, the gyroplane must be able to demonstrate a history of safe operation <u>and</u> the non-ultralight standards shall be clearly placarded in the cockpit to provide notice to the occupants.

<u>NOTE:</u> - The ASRA Board at all times reserves the right to **deny** listing where the Board deems that there is a risk that the non-ultralight feature may possibly give rise to a serious and imminent risk to flight safety.

(c) Rotor Teeter Range

(i) ASRA notes that UK scientific research has established that a rotor assembly in flight can easily teeter up to plus-or-minus **8 degrees** within the hub if control inputs are abrupt. Therefore, ASRA ***strongly recommends*** that measured static rotor teeter ranges be not less than plus or minus 8 degrees (i.e., total range **16 degrees**).

WARNING

Extreme care must be exercised by operators who swap out rotor assemblies made by different manufacturers into their gyroplanes. If such swapping occurs it is essential that the existence of adequate static teeter range be checked and measured before flight is resumed.

NOTE: - A constrained teeter range is implicated in one Australian fatality.

(ii) That the range stated above at (i) is mandatory for gyroplanes constructed within Australia, either as builds-to-order, home-builds, hybrid conversions, or for the restoring or rebuilding of gyroplanes previously manufactured by companies that are no longer in business.

(iii) In the case of gyroplanes manufactured as an identifiable and identical type by a company or companies that are still operating, where it is found that the teeter ranges of an inspected gyroplane are at variance in some respect from that specified above at (i), the matter is to be referred to the Head of Flight Operations (HOFO). Unless otherwise approved by the Head of Flight Operations (HOFO), minimal non-compliances in commercially manufactured gyroplanes will require that the non-complaint gyroplane be placarded to give occupants notice of the non-complaint aspect.

NOTE: - The ASRA Board at all times reserves the right to **deny** listing where the Board deems that there is a risk that the non-ultralight feature may possibly give rise to a serious and imminent risk to flight safety.

D102 Rotor Clearances

When a gyroplane rotor is generating lift sufficient for flight the long axis of each blade will generally "cone" upward at between 2 to 3 degrees. During ground operations, however, particularly at lower rpm, the blades will be much closer to horizontal or might even droop downward toward the tips due to weight of the blade. Rotor blades at low rpm are susceptible to being affected by wind gusts (known as "blade sailing") and will not respond quickly to control stick movements intended to counter the up or down movement of the gust affected blade. It is in these circumstances that an expensive rotor-to-tail strike is likely to occur.

With the rotor head assembly tilted aft until it rests on the aft tilt stop and with the rotor blade pulled down so that it rests on the teeter stop and is in line with a vertical propeller blade.

(a) the clearance between the underside of the rotor blade and the tip of the vertical propeller blade shall be a minimum of 50 mm.
(b) the rotor blade shall remain clear of the tail surfaces.
(c) the minimum clearance from the top of pre-rotator is 12mm.

NOTE CAREFULLY - Different rotors have different degrees of rigidity and stiffness in the static state and each owner and/or operator must consider very carefully whether there is enough rotor-to-tail clearance to cope with a gust of wind further deflecting downward a slow-turning drooping rotor.

OWNER/OPERATORS ARE COMPLETELY ASSUMING THEIR OWN RISK FOR GROUNDHANDLING ROTOR TAIL STRIKE DAMAGE. IF THE OWNER/OPERATOR HAS CONCERNS THAT A TAIL STRIKE MIGHT OCCUR CAUSED BY A WIND GUST DEFLECTING A SLOWING DROOPING ROTOR THE MANUFACTURER OR IMPORTER IS TO BE CONSULTED. FOR HOMEBUILTS THE PRINCIPAL CONSTRUCTOR SHOULD CONSIDER INCREASING THE HEIGHT OF THE MAST OR SHORTENING OR LOWERING THE VERTICAL TAIL SURFACES.

D105 Rotor Head Bearings

All rotor head bearings,

(a) Must have specifications that ensure that they have the strength and other properties assumed by the gyroplane designer, and
(b) Must have their suitability established by experience or evaluation.

D107 Rotor Attributes

(a) Rotor Disc Loading

Rotor disc loading is a calculation of gross weight divided by the rotor disc area of the gyro. The preferred units for these calculations are pounds and square feet, as most rotor diameters are reckoned in feet rather than metres.

For instance, a 28-foot diameter rotor has a disc area of 615 square feet. If the gross weight of the gyro is 1,322 pounds (600 kg) then its disc loading will be 1322 / 616 = 2.146 pounds per square foot.

Noted U.S. gyroplane designer the late Dr Martin Hollmann in his master's thesis determined that a gyroplane's disc loading should **ideally not exceed 1.8 pounds per square foot**, and he recommended that the disc loading should preferably be lower than that if at all possible. In gyro terms, a high disc loading will result in long take-off runs, poor climb, slower cruise and very high sink rates. A lower disc loading will result in shorter take-off runs, much better climb, faster cruise and moderate sink rates.

The following table lists ideal disc loadings based on rotor diameter:

Diameter	Disc Area in Square feet	Gross weight at 1.8 lbs per sq ft disc loading
22 feet	380.133 square feet	684.24 lb / 310.36 kg
23 feet	415.476 square feet	747.85 lb / 339.22 kg
24 feet	452.389 square feet	814.30 lb / 369.36 kg
25 feet	490.874 square feet	883.57 lb / 400.78 kg
26 feet	530.929 square feet	955.67 lb / 438.02 kg
27 feet	572.555 square feet	1030.59 lb / 467.46 kg
28 feet	615.752 square feet	1108.35 lb / 502.74 kg
29 feet	660.520 square feet	1188.93 lb / 539.29 kg
30 feet	706.858 square feet	1272.34 lb / 577.12 kg

(b) Power Loading

Dr Hollmann determined that disk loading and power loading were key indicators of likely gyroplane performance. A gyro with optimal disc loading can still be completely compromised by having too low a power loading.

Dr Hollmann recommended that gyroplane designers should plan an engine/airframe power combination of **no greater than 9 pounds weight for every 1 horsepower (in metric this is a maximum of 4 kg per horsepower).** Therefore, a gyroplane flying at 600 kg gross weight on Dr Hollmann's recommendations should have 150 hp installed.

Most Australian gyroplanes do not yet come up to Dr Hollmann's recommendations, but most are nonetheless capable of very acceptable performance especially in skilled hands.

A review of Australian gyroplanes in 2011 determined that most Australian gyroplanes at that time had a power loading of between 9 to 11 pounds per horsepower.
Anecdotally, installed available horsepower has been increasing in recent years. It is now increasingly common to encounter Rotax 912 aftermarket turbo derivatives capable of putting out between 135 and 146 horsepower.

(c) Rotor RPM

Rotor rpm in autorotation is dictated firstly by the ratio of the combined rotor blade upper surface area divided by the total rotor disk area (the "solidity ratio"), then secondly by taking into account the amount of weight the rotor will be carrying. This second parameter is called the "blade loading", which is the ratio of the combined upper surface area of the 2 rotors blades combined, divided by the gross weight of the gyro.
The "solidity ratio" is the ratio of the area of the 2 rotor blades to the total disc area. To be precise, it is best to imagine the rotor system drawn on paper as a circle then with the 2 blades drawn in scale within that circle. For a 2-blade rotor each rotor blade is measured from where the blade surface commences near the blade root out to the tip in inches, and then measured from leading edge to trailing edge in inches (the blade chord). These 2 measurements are multiplied together to get the area of each blade in square feet.

For example, a single blade from a 25-foot diameter rotor is likely to have a measurement of 11.5 feet of effective blade surface and is likely to have something like with a chord measurement of 9 inches. This results in 9 x 138 inches = 1,242 square inches, divided by 144 = 8.625 square feet per blade.

A 25-foot rotor "disc" has an area of 490.874 square feet. To work out the solidity ratio you divide the area of the 2 blades combined by the total disc area: 17.25 divided by 490.874 = **0.035**. The solidity ratio is therefore **0.035**. Typical 2-bladed solidity ratios in helicopters and gyroplanes range between **0.035 to 0.040**.

<u>Dr Hollmann suggests that 0.035 should be considered the minimum value for 2-bladed rotors</u>

Because solidity ratio is expressed as a fraction of disc area, it follows that to maintain the 0.035 to 0.040 ratio as the disc area increases, the rotor blade chord should also be increasing. Therefore ideally, the chord of gyroplane rotor blades or larger diameter setups should ideally be in the region of 10 or 11 inches instead of 8 or 9 inches.

However, real-world gyroplane blade chords seldom exceed 9 to 10 inches principally because much of the gyroplane fleet are using extruded aluminium rotors and experience has shown that the manufacturing failure rate of rotor blade cross-section extrusions skyrockets at 10 inches or larger, therefore becoming uneconomic to produce.

Similarly, composite rotor manufacturers tend to create blades with a single chord measurement, then chop the blades off to produce smaller diameters if needed. Again, it would be uneconomic to produce multiple moulds with increasing chord sizes. That's also why tapered blades are seldom produced – too difficult to manufacture economically.

(d) Blade Loading

Blade loading is determined by dividing the combined surface area of the rotor blades by the gross weight, or by the operational weight if considering a specific operational scenario. Remarkably accurate predictions of rotor rpm can be made by considering blade loading.

The basic rule-of-thumb is that rotors with larger chord blades will spin slower than those with shorter chord blades.
Once the blade loading is known, a remarkably accurate estimate of the ultimate rotor rpm can be made:

Table of Contents

(i) assuming the NACA 8-H-12 airfoil is used with the standard pre-set incidence or geometric pitch of 1.5 degrees, and using the same 138 x 9-inch area for each blade used in the preceding section, the total combined blade area is 17.25 sq ft. If the single-seat gyroplane has a gross weight of 881 pounds, this results in a blade loading of 51 pounds per square foot.
(ii) work out the square root of the blade loading: root 51 is 7.1414.
(ii) multiply 7.1414 by 66 = 471.33 fps tip speed.
(iv) multiply 471.33 x 60 to get the circumferential distance travelled by the rotor tip in one minute = 28,279.8 feet.
(v) divide the rotor circumference into that figure to arrive at the rotor rpm prediction: 78.54 feet divided into 28,279.8 = **360 rpm**.

<u>Real-world gyro rotor rpm</u>

Mainly because of the manufacturing constraints on rotor chord discussed above as well as the regulatory gross-weight limitations imposed by governments, practical gyroplane operation usually sees the rotor rpm somewhere between 300 to 400 rpm.
Because the fixed-pitch semi-rigid 2-bladed rotor is incapable of having blade pitch or incidence changed in flight, under autorotation the rotor will settle down into a remarkably stable rpm somewhere between 340rpm up to 400rpm. The rotor rpm will increase slightly with higher airspeeds and will also transiently increase during manoeuvring or in turbulence. The operational weight of the gyro at any given moment also will affect rotor rpm.

(e) Static Thrust
ASRA strongly recommends that for satisfactory performance, a gyroplane should have sufficient installed power to produce a static thrust when tied to a fencepost or tree of **<u>not less than half the gross weight of the gyroplane</u>**. The usual method is for a scale capable of measuring not less than 500 kg to be placed somewhere along the rope restraint. This must always be a minimum 2-person procedure. The pilot-in-command must be seated and restrained by seat belts in the gyroplane. The helper is to be the person who records the scale readings.

<u>NOTE:</u> - CASA CAO Instruments 95.12 and 95.12.1 of 2011 mandate that a gyroplane disc loading must not exceed 20 kilograms per square metre. In imperial measurements, this calculates out to 4.096 pounds per square foot disk loading. This must be regarded as a <u>regulatory limit</u> only, because safe and effective gyroplane operation can only be achieved at half that disk loading.

CONTROL SYSTEMS

D110 General

Each control must operate easily, smoothly and positively enough to allow proper performance of its functions.
For full travel of the control column the movement must be between 250 mm and 300 mm in the longitudinal plane (Fore and Aft) and between 200 mm to 250 mm lateral movement (roll).

D115 Stops

(a) Each control system must have stops that positively limit the range of motion of the pilot's controls.
(b) Each control system must have stops or other mechanical limitations to prevent positively possible interference with other control systems or moving components (that is, rudder stops to prevent interference with propeller).
(c) Each stop must be located so that wear, slackness, or take-up adjustments will not adversely affect the control characteristics of the gyroplane because of a change in the range of travel of the control.
(d) Each stop must be able to withstand any loads corresponding to the design conditions for that control.
(e) Control system stops must be in the rotor head to avoid excessive control rod and control column loads.

Table of Contents

D125 Trim System

(a) If a trim system is fitted which is operable in flight, proper precautions must be taken to prevent inadvertent, improper, or abrupt trim operation.

(b) There must be means near the trim control to indicate to the pilot the direction of trim control movement relative to the gyroplane motion and a means to clearly indicate the position of the trim device with respect to the range of adjustment.

(c) The trimmed range must be limited so that stick force cannot exceed 2.27 kg (5 lbs) on take-off or during level flight.

D135 Control System Details

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

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

(c) There must be means to prevent the slapping of cables, tubes, or 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 that could result in malfunctioning of the control system.

(e) Where bell-cranks are used in any control system, they must be so designed that their range of travel is limited to a maximum of 45° each side of the mean position in respect to any movement measured at that bell-crank. The mean position is when the centre line between the bell-crank pivot and the bell-crank push/pull rod mount is at right angles to the push/pull rod.

(f) Secondary controls must maintain any desired position without requiring constant attention by the pilot.

(g) Friction devices fitted to throttles must be hand adjustable.

(h) A guard must be provided to prevent rudder cables from entering the propeller arc.

D145 Cable Systems

WARNING

Care must be taken to ensure that the swaging (crimping) tool is calibrated for the type of hardware upon which it will be used, be that metric or imperial. Failure to adhere to this caution may result in improperly swaged terminals that may result in in-flight failure.

(a) Each cable, cable fitting, turnbuckle, splice, and pulley used must meet stated specifications. In addition: -

  (i) No cable smaller than 2.4 mm (3/32 in.) diameter or, as the manufacturer specifies, may be used in primary control systems (ASRA preferred – 316 grade stainless steel).

  (ii) 7 by 19 strand flexible control cable shall be used in primary control systems.

  (iii) Each cable system must be designed so that there will be no hazardous change in cable tension throughout the range of travel under operating conditions and temperature variations; and

  (iv) There must be means for visual inspection at each fairlead, pulley, terminal, and turnbuckle. This requirement precludes the use of heat shrink plastics to cover swaged terminals. Heat shrink plastic may be used on the ends of cables only to prevent fraying. It is further recommended that a suitable material be used on the cables either side of a swaged terminal in order to detect early movement of the cables through a swage. Nail polish has proven to be such a material.

(b) Each kind and size of pulley must correspond to the cable with which it is used. Each pulley must have closely fitted guards to prevent the cables from being misplaced or fouled, even when slack. Each pulley must lie in the plane passing through the cable so that the cable does not rub against the pulley flange.

(c) Fairleads must be installed so that they do not cause a change in cable direction of more than 3°, except where evaluation or experience indicate that a higher value would be satisfactory. The radius of curvature of fairleads must not be smaller than the radius of a pulley for the same cable.
(d) Turnbuckles attached to parts having angular motion must be done so in a manner that will positively prevent binding throughout the range of travel.
(e) Use of bridle cables clamped directly to rudder cables to affect nose or tail wheel steering is prohibited.

D147 Swivel Rod Ends

The strength of swivel rod ends used in control system joints must be established by experience or evaluation. In some cases, figures may be required for compression as well as tension.

D150 Joints

(a) Control system joints (in push-pull systems) that are subject to angular motion, except those in ball, roller and spherical bearing systems, must have a special factor of safety of not less than 3.33 with respect to the ultimate bearing strength of the softest material used as a bearing. This factor may be reduced to 2.0 for joints in cable control systems. For ball, roller or spherical bearings, the approved ratings must not be exceeded.
(b) Rod end bearing spherical ball attachment (in push-pull systems): -
  (i) Double Shear—The bolt through the spherical ball in rod end bearings (in push-pull systems) is preferred to be rigidly captured on both sides of the ball (double shear) so as not to put cantilever forces on the bolt.
  (ii) Single Shear—Cantilevered bolt arrangement is permissible if bolt and the structure can be demonstrated to be appropriately robust to prevent flexure or fatigue, or both, of the structure or bolt, and the bolt is installed with its threaded portion inside the arm such that there is no significant bending on the threaded portion of the bolt.
(c) The rod end bearing threads must use a locknut, or other locking means, to prevent the threaded joint from turning on its threads.
(d) Special care shall be made that the spherical ball in the rod end bearings does not limit travel of the controls and that undue bending forces are not put on the rod end bearings.
(e) Push-pull rods using rod end bearings on both ends should have freedom to twist at all extremes of the control inputs.

COCKPIT DESIGN

D155 General

The cockpit and its equipment must allow the pilot(s) to perform his or her duties without unreasonable concentration or fatigue.

D160 Cockpit View

Each cockpit must be designed so that: -
(a) The pilot's field of view is sufficiently extensive, clear and undistorted, and must be such that rain must does not unduly impair his view along the flight path in normal flight and during landing, Vision may be provided by any canopy having a suitable opening.
(b) The pilot is easily able to establish a pitch attitude by reference to a fixed point on the airframe when looking forward.

D165 Windshields Windows and Doors

(a) Windshields and windows, if fitted, must be constructed of a material that will not break into dangerous fragments or become opaque when damaged.
(b) There must be provision to secure, if fitted, each door, window, compartment cover and inspection covers.
(c) There must be a means to safeguard each door against inadvertently opening inflight unless:
  (i) it is designed so that, in the event of a malfunction of their latching mechanisms, they will not be forced open by the action of the slipstream; or
  (ii) a door opening in flight does not adversely affect the safe operation of the aircraft or cause undue distraction to the pilot; or

(iii) it can be shown that any door that is not closed and secured would be clearly evident to the crew from their normal operating position(s) before flight.

D170 Cockpit Controls

(a) Each cockpit control must be located to provide convenient operation, and to prevent confusion and inadvertent operation.

(b) The controls must be located and arranged so that the pilot, or pilots, when properly secured by a safety harness, has full and unrestricted movement of all essential controls (Including allowance for bulky winter clothing.).

D185 Safety Harnesses

(a) The 4-point safety harness is required to be of a type that consists of 2 lap straps and 2 shoulder straps. Each strap is required to meet in a quick release central buckle.

(b) The strength of the safety harness must not be less than that following from the ultimate loads for the flight and ground load conditions and for the emergency landing conditions according to C100 (b) considering the geometry of the harness and seat arrangement.

(c) Shoulder harnesses must attach at a point on the airframe that would not be likely to depart the airframe forcibly upon a crash or result in ancillary occupant injury such as spinal compression.

(d) Each safety harness must be attached so that the wearer is safely retained in the initial sitting position under flight and emergency landing accelerations.

See Figures 1, 2 and 3.

D190 Protection from Injury

Rigid structural members, or rigidly mounted items of equipment, must be padded where necessary to protect the occupant(s) from injury during minor crash conditions.

D200 Emergency Exit

(a) The cockpit must be so designed as to provide occupant/s with unimpeded and rapid escape in an emergency.

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

D205 Ventilation

When there is an enclosed cockpit, it must be designed so as to afford suitable ventilation under normal flying conditions.

SUBPART E – Powerplant

GENERAL

E5 Installation

The powerplant must be constructed, arranged and installed to: -

(i) Ensure safe operation between normal inspection and overhaul and
(ii) Be accessible for necessary inspections and maintenance.

E10 Compatibility

Each combination of engine and propeller in a gyroplane for which a listing certificate is sought must be compatible with the gyroplane, and functions in a satisfactory manner. It must be free from excessive vibration under each appropriate speed and power setting.

E15 Rotor Spin-up and Brake Systems

If a rotor spin-up or brake system is installed, it must be designed to prevent: -

(i) It remaining engaged on take-off, and
(ii) It becoming engaged in flight.

Limitations on the use of any rotor spin-up or brake systems must be specified in the Flight Manual.

E20 Flight Endurance Evaluation

(a) It shall be confirmed by flight evaluation that the proposed powerplant and rotor system limitations are compatible with the satisfactory functioning of the system over the proposed range of operating conditions and flight envelope.

(b) A 40-hour flight endurance evaluation shall be conducted on a provisionally listed gyroplane, to demonstrate the following:

   (i) The gyroplane must not experience any significant problems or failures during the endurance evaluation.

   (ii) The endurance evaluation must be conducted to a flight schedule which is representative of operational use.

   (iii) Any problems or failures which occur must be resolved and extra flight evaluations conducted until 40 hours of trouble-free operation has accrued.

   (iv) Development flying time may be counted towards the 40 hours of endurance evaluation, provided the gyroplane is in the final configuration and the evaluation flying was representative of operational use.

   (v) in any particular case, the Head of Flight Operations (HOFO) and the Head of Airworthiness and Maintenance (HAM) deciding jointly - may vary the 40-hour period by either reducing or increasing the hours as the case may be and depending on the particular circumstances that exist with the subject gyroplane at the time.

E25 Propeller Clearance

Propeller clearance taking account of likely airframe flexibility, must not be less than the following: -

(i) At least 50 mm radial clearance between the blade tips and other parts of the gyroplane, plus any additional radial clearance, if necessary, to prevent harmful vibration and to allow for engine mount flexibility.
(ii) Adequate longitudinal clearance between the propeller blades or cuffs and other parts of the gyroplane or engine to allow for engine movement and the flexibility of the propeller.
(iii) Positive clearance between all rotating parts of the propeller and spinner and other parts of the gyroplane under all operating conditions.

FUEL SYSTEM

E30 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 normal operating condition.

E35 Fuel Flow

The fuel flow rate must be at least 125% of the actual take-off fuel consumption of the engine at the maximum power established for take-off.

E40 Fuel Quantity

(a) The useable fuel quantity for each tank must be established as not less than that quantity at which the first evidence of engine fuel starvation occurs under the most adverse fuel feed conditions occurring during take-off, climb, approach, and landing involving that tank.

(b) The unusable fuel quantity must be established and identified on the fuel level indicator or indicating device

E45 Integrity of Fuel Tanks

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

(b) Where surging of fuel within the tank could cause significant changes in the centre of gravity of the gyroplane, means must be provided to reduce the surging to within acceptable limits.

E55 Fuel Tank Installation

Fuel tanks must be supported so that the loads resulting from the weight of the fuel are not concentrated. The fuel filler cap must not be rigidly fixed to an aircrew enclosure or to the gyroplane structure if it is possible, during a heavy landing for the fuel filler pipe to be ruptured or detached by deformation of the enclosure or movement of the tank with respect to the gyroplane structure. The fuel outlet pipe must have sufficient excess length to significantly reduce the likelihood of the fuel outlet lines being ruptured or detached if the tank should move with respect to the surrounding structure during a heavy landing. Any compartment containing a fuel tank must be ventilated and drained to prevent accumulation of flammable fluids and vapours.

E60 Fuel Tank Sump

(a) Each fuel tank, if permanently installed, must have a drainable sump or a drainable fuel sediment bowl of at least 25ml.

(b) The fuel system drain must be readily accessible and must have positive locking in the closed position.

(c) Each tank outlet must be located so that, in the normal ground attitude, water draining from any part of the tank will accumulate in the sediment bowl or chamber.

E65 Fuel Tank Filler Connection

Fuel tank filler connections must be located outside the cockpit or must be located so that overflowed or spilled fuel runs overboard, and so that fuel or fuel vapours cannot enter any closed compartment of the gyroplane.

E70 Fuel Tank Vents

Each fuel tank must be vented from the top of the tank and must discharge clear of the gyroplane.

E75 Fuel Strainer or Filter

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

NOTE: - In some pressure fuel systems, a filter between the tank and pump is not appropriate. Such installations will be considered on their merits.

(b) Each filter or strainer must be easily accessible for cleaning or replacing.

E80 Fuel System Lines and Fittings

(a) Each fuel line must be installed and supported to prevent excessive vibration.

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

OIL SYSTEM

E90 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 a usable capacity adequate for the endurance of the gyroplane.

E95 Oil Tanks

(a) Where an oil tank is fitted, it must be installed to withstand any vibration, inertia and fluid loads expected in normal operation.
(b) The oil level must be easy to check without having to use any tools
(c) If the oil tank is installed in the engine compartment it must be made of fireproof material.

E105 Oil Lines and Fittings

(a) Oil lines must comply with E80 and accommodate a flow of oil at a rate and pressure adequate for proper engine functioning under any normal operating conditions.
(b) Breather lines must be arranged so that the breather discharge will not constitute a fire hazard if foaming occurs or cause emitted oil to strike the pilot's windshields.

COOLING

E110 General

The powerplant cooling provisions must be able to maintain the temperatures of powerplant components and engine fluids within normal temperature limits during all likely operating conditions.

INDUCTION SYSTEM

E115 Air Induction

The air induction system for the engine must supply the air required by the engine under all intended operating conditions. Compliance may be shown by satisfactory completion of the flight endurance evaluation of E20.

EXHAUST SYSTEM

E120 General

The exhaust and silencing system must ensure safe disposal of exhaust gases without fire hazard or carbon monoxide contamination in the cockpit. In addition: -

(a) It must be supported to withstand the vibration and inertia loads to which it may be subjected in normal operation
(b) If the design of the exhaust system is such that after a failure in the exhaust system it can interfere with the propeller, additional restraint must be provided to ensure a degree of redundancy in the exhaust mounting.

POWERPLANT CONTROLS AND ACCESSORIES

E135 Engine Ignition System

(a) A switch, readily accessible to the pilot, must be provided to enable each ignition circuit to be rendered inoperative.
(b) The ignition switch(s) must be arranged and designed to prevent inadvertent operation.

E140 Propeller Speed

During take-off and climb at the recommended best rate-of-climb speed, the propeller must limit the engine rotational speed at full throttle to a value not greater than the maximum allowable rotational speed.

E145 Cowling and Nacelle

When an engine installation is cowled, the cowling must be so designed as to resist any vibration, inertia and air loads, and should not in any way cause a fire hazard.

SUBPART F – Equipment

GENERAL

F10 Flight and Navigation Instruments

The following flight and navigational instruments are required to be fitted: -

(a) An air speed indicator (calibrated in knots).
(b) An altimeter (calibrated in feet).
(c) A yaw indicator.

F15 Powerplant Instruments

The following are the required power plant instruments: -

(a) Such pressure, temperature and RPM indicators as are necessary to operate the engine within its limitations.
(b) Where a non-magneto ignition system (battery and ignition coil) is used, a voltmeter is required to monitor the battery voltage.
(c) A fuel quantity indicator; and
(d) An oil quantity indicator, (e.g. dipstick).

NOTE: - Each exposed sight gauge used as a liquid quantity indicator must be protected against damage. The low-level indication range of the indicator must be plainly visible to the pilot.

ELECTRICAL SYSTEMS AND EQUIPMENT

F45 Electric Cables and Equipment

(a) Each electric connecting cable must be of adequate capacity and correctly routed, attached and connected so as to minimise the probability, short circuits and fire hazards.
(b) Overload protection must be provided for each electrical circuit.
(c) Engine, fuel tank and other parts of the gyroplane, which are electrically conductive must be earthed to the main frame.

F50 External Lights

The installation and use of a flashing beacon/strobe is mandatory for operations at certified or registered aerodromes.
In the interests of safety, ASRA recommends that the flashing beacon/strobe be operating at all times during flight.

MISCELLANEOUS EQUIPMENT

F55 Airborne Radio and Radio Navigation Equipment.

Each item of airborne radio equipment must comply with the following: -

(a) The equipment and its aerials must not constitute a hazard to safe operation of the gyroplane.
(b) The equipment and its control and monitoring devices must be arranged so as to be easily controllable

SUBPART G - Operating Limitations and Information

G10 Air-speed Limitations

All flight speeds must be stated in terms of indicated airspeed (IAS).

G20 Power plant and Propeller Limitations

The power plant limitations must be established on the basis of manufacturers specifications or experience. The suitability and durability of materials used in the propeller must be established on the basis of experience or evaluation. The maximum rotational speed of the propeller must not exceed that recommended by the manufacturer.

G25 Flight Manual or Pilot Operating Handbook

Each gyroplane must be provided with an ASRA approved Flight Manual applicable to that aircraft.

(a) Content of the Flight Manual

B10	Load Distribution Limits (Hang Test)
B15	Maximum Weight
B20	Empty Weight
B32	Rotor Speed Limits
B40	Take-off Distance
B45	Climb Rate
B50	Minimum Sink Rate
B52	Best Glide Ratio
B55	Never Exceed Airspeed (VNE)
B60	Minimum Controllable Speed for Level Flight (VMIN)
B65	Best Rate of Climb Airspeed (VY)
B70	Landing Distance
B75	Maximum Operating Altitude
B80	Height/Velocity Envelope
B85 (a)	Controllability and Manoeuvrability
B85 (d)	Procedure for Landing at Engine Idle
B90	Operations in Windy Conditions
B125	Maximum Ground Speeds
E15	Rotor spin up limits
E40	Unusable Fuel Quantity
G5	Operating limitation
G20	Powerplant and Propeller Limitations

(b) Maintenance Program

The Flight Manual will contain the approved maintenance program for the gyroplane.

(c) Other Entries

Any other matter which will affect the safe operation of the particular gyroplane must also be entered into the Flight Manual.

MARKINGS and PLACARDS

G30 General

Limitations essential to the safe operation of the gyroplane must be plainly visible to the pilot

G45 Fuel Quantity Indicator

Each fuel quantity indicator must be visible to the pilot in flight and be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable quantity determined in accordance with E40.

Table of Contents

G50 Control Markings

(a) Each cockpit control, other than primary flight controls, must be clearly marked as to its function and method of operation.

(b) Emergency controls must be coloured red.

(c) For powerplant fuel controls: -

- (i) The fuel tank selector control (if fitted) must be marked to indicate the position corresponding to each tank; and
- (ii) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on or near the selector for those tanks.

G55 Miscellaneous Markings and Placards

(a) Baggage compartment. Each baggage compartment must have placard stating the loading limitations.

(b) Fuel filler opening must be marked at or near the filler cover with the minimum fuel grade and if applicable the fuel/oil ratio.

(c) The useable fuel capacity of each tank must be marked either at the selector or the gauge or on the tank if this is translucent and visible to the pilot in flight.

(d) Gyroplane Listing markings are the letter ‘G’ followed by either 3 or 4 numbers as assigned. The prescribed markings must: -

- (iii) be painted on the aircraft or be affixed to it by any other means that ensure an equivalent degree of permanence for the markings; and
- (iv) be legible and have no ornamentation; and
- (v) be of a colour that contrasts with their background; and
- (vi) be clearly visible at all times; and
- (vii) 2 sets of the aircraft’s prescribed markings must be displayed horizontally, with one set on each side of the cabin, fuselage, boom or tail.

The characters must be: -

- (i) of the same height; and
- (ii) not less than 75mm (150mm recommended); and
- (iii) equal in width to two thirds of the character height except the numeral “1”, whose width must be equal to one sixth of its height, and the letters “M” and “W” which may be equal to their height; and
- (iv) made up from solid lines that are one sixth as thick as the character height; and
- (v) positioned so that the space between any two characters is not less than one sixth of the character height; and
- (vi) where space is not available, the height shall be as large as is practicable.

(e) For a single place gyroplane, a placard showing an occupant warning must be plainly visible to the pilot when occupying the control seat, as follows: -

> "Neither CASA nor ASRA guarantee the airworthiness of the gyroplane. The pilot operates the gyroplane at the pilot's own risk."

INSTALLATION OF SHOULDER HARNESS

Figures 1, 2 and 3 below show the required installation geometry for this type of restraint.

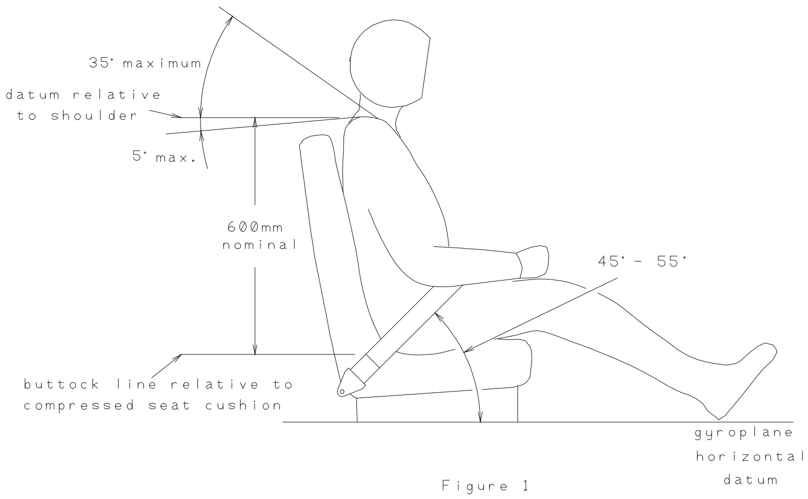


Figure 1

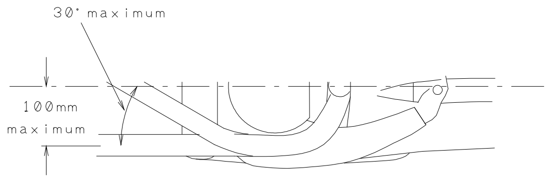


Figure 2

Range of Angles of Sholder Straps

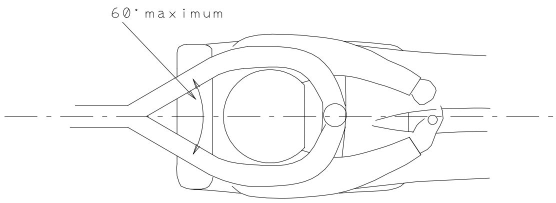
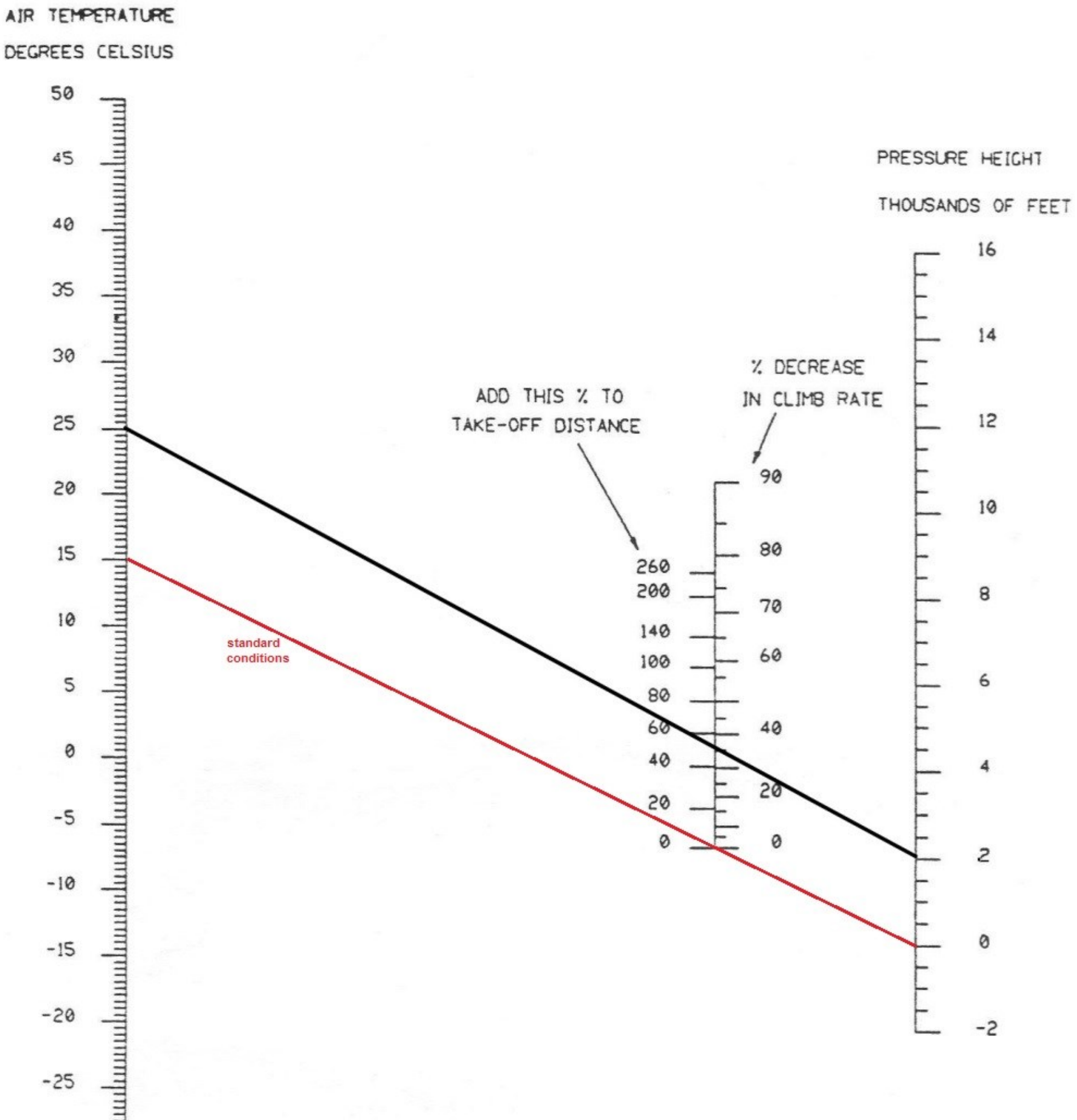


Figure 3

NOMOGRAPH OF EFFECTS OF TEMPRATURE AND ALTITUDE ON CLIMB RATES



Effects of Temp and Altitude.

Example: The diagonal line shows that 50% increase in takeoff distance must be added for a temperature of 25deg C. and a pressure altitude of 2,OOOft.. Therefore if your standard temperature sea level take-off distance, in order to climb to 5Oft., normally requires l,OOOft. of runway, it would become 1,5OOft, under the conditions shown. In addition, the rate of climb would decrease 30%, meaning that if your normal sea level rate of climb is 5OOft. per minute, it would become 350ft per minute.

APPENDIX 1

The Approved ASRA Method – Hang Testing

Minimum 500 kg hoist required for 2 stroke single seaters.

Minimum 1000 kg hoist required for all other gyroplanes.

Step 1 – Decide on your reference surfaces

Firstly, while the gyro sits on its main-wheels and nose-wheel, decide whether there are any useful reference lines on the gyro itself when viewed from the side. For instance, if a gyro's keel is perfectly horizontal and the mast is tilted back 10 degrees, then these are perfect ready references that will really make it easy for you to judge hang angles. The front or rear edge of the mast is usually one of the best reference lines if the keel is not visible, horizontal or straight. Also, you need to bear in mind whether your gyro flies slightly nose-up or nose-down – studying in-flight photos can usually help you decide whether the keel is parallel with the horizon or not.

Step 2 – set up some fluoro "brickies string line" as a vertical visual reference

This needs to be strung from the teeter bolt with a plumb-bob or similar on the bottom, long enough to reach to about wheel level. If tied to the end of the teeter bolt it may have to be draped over parts of the head, such as the pre-rotator ring gear (if fitted) or other parts of the frame. Make sure that it always hangs in line with the teeter bolt when viewed from where the camera has been set up.

Step 3 – Locking the torque tube

Next, the rotor head torque or bar tube is to be restrained at exactly the mid-point between the forward and rear pitch stops – this is most easily accomplished by cutting 1 or 2 hardwood wedges to suit and securely taping them in position (the test can be done satisfactorily with 1 wedge at the front only). Under no circumstances is the torque tube or bar to be locked by jamming the control stick in the mid-position – this will place too much strain on the control rods and links. (Members are reminded that the forward and rear limits of the control stick travel must always be as a result of the rotor head torque tube or bar touching the forward and rear stops at the rotor head, and NOT because the stick is contacting surfaces in the cockpit before the rotor head stops are touched).

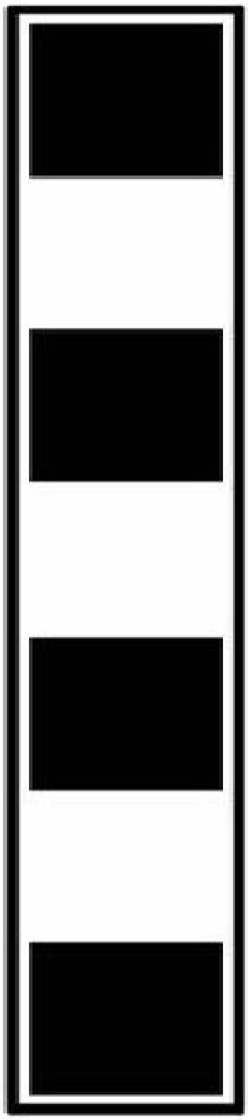
Step 4 – Stick the reference scale on the mast and make your signs up

Next, create the reference scale (on the right) and stick it on the side of the mast. This scale is exactly 7 inches long and will be used as a reference when doing the final plotting on the resulting photographs of the hang and tilt-back test processes. Also, make up your A4 sized signs for "Full Fuel" or "No Fuel."

Step 5 – Decide whether to rig up a string line to show your propeller thrust line or to do it later on computer

While you are fiddling with flouro brickies string line, this is the ideal time (if you want) to tie some carefully around your propeller hub and pull it forward tightly to the front of the gyro to represent your propeller thrust line. Make sure that the thrust-line string is exactly lined up with the centre of the propeller hub when viewed from the camera, and also make sure that the string is exactly perpendicular (90 degrees) to the propeller blades. This stringing must be done very, very carefully. The front of this string line will usually have to be tied to an aerial or temporary stick set up near the front.

Because of the likelihood that this string might interfere with the pod or the occupant, some people prefer not to bother with stringing the propeller thrust line and opt to simply draw the line in on the photographs during the final plotting stage. It's really up to you.



Step 6 – Loading, Hoisting and Photographing

Next, place the required amount of fuel and occupant in the gyroplane and safely hoist off the ground.

The occupant in single seaters is to be the customary pilot (usually the registrant).

This test MUST be photographically recorded with a reasonable quality digital camera. The camera should set up level on a tripod far enough away from the gyro so that the entire machine is visible including the hanging point. The gyroplane MUST be swung so that the long axis or centreline of the gyro is exactly perpendicular (or 90 degrees) to the camera and the camera itself should be aimed directly at the brickies string line. Before taking the photo of the hang-test always double-check that the string line and teeter bolt are perfectly in line. Then, take 2 or 3 pictures.

<u>The ASRA Recommended Hang Angles</u>

With full tanks and occupant on board, the gyroplane should hang nose down at not more than 12 degrees. If the gyroplane hangs nose-down at a greater angle than this, then a new set of cheek plates might need to be made to move the head forward.

With empty tanks and occupant on board, the gyroplane should hang nose down not less than 9 degrees. If the gyroplane hangs nose-down at a lesser angle than this, then a new set of cheek plates might need to be made to move the head rearward.

Any moving of the rotor head forward or rearward needs to be done very carefully to ensure that the control rods remain well clear of other parts of the gyroplane structure after the shift, and that the original or usual relationship between control stick movement and torque tube or bar movement is preserved.

No Ballasting and Cheating Please

Ballasting of a gyroplane to bring it into forward and back hang-test recommended limits is NOT AUTHORISED. Added weight must NEVER be used to correct poor hang-balance, other than where a 2-seat side-by-side gyroplane cannot be flown solo other than with a pre-set amount of ballast (as in with the Purnong accident-gyro).

Also, ASRA full well knows that some members might be very tempted to pile in 4 or 5 bricks into the front of a pod or tape a steel bar to the opposite side of the rear keel, to get a machine to hang properly for the photographic phase of the testing.

ASRA urges that members don't give in to any such temptation – the whole point of the exercise is to "get it right" – not to "fudge" the results.

<u>If your gyro is not hanging within recommended limits</u>

If your gyroplane hangs outside ONE or BOTH limits it might be a sign that you have a few problems! A Technical Advisor should be consulted.

ASRA suggests that if your gyroplane comes up outside these recommended limits when you initially hang test, then you should consult a TA and take your time to bring the gyroplane within limits and do repeat hang-testing before you ultimately submit your hang-test results. ASRA prefers those members “get it right” before formally submitting their photographic evidence.

The Approved ASRA Method – Tilt-Back (or Balance) Testing

This process is vital to provide a 2nd reference line on photographs to enable the vertical centre of gravity to be accurately plotted.

ASRA much prefers that the tilt-back test be done at the same site and same time as the hang testing, because the gyroplane can be safely raised and lowered using the same hoist used during the hang-testing. Furthermore, it is much safer to use a hoist because a slightly slackened rope can be kept around the rotor head to prevent the gyroplane overbalancing either forward or back during the tilt-back. The whole idea of the exercise is to get the gyroplane (with rotors ON) to teeter or balance on its main wheels. The process needs to be done with at least a couple of people carefully holding, tilting and safely restraining the gyroplane as it tilts back toward the balance point.

Obviously, the main wheels have to be quite high off the ground to allow the tail to tilt back and down. The usual height is about 18 inches or 50cm. The stands used for the main-wheels to sit on must be sufficiently strong, and the main-wheels must be securely chocked in position. Some people use car or truck ramps, although this is not the ASRA preferred method because of the risks and hazards associated with the gyroplanes rolling suddenly down off the ramps.

Step 1 – Remove the weighted string line from the teeter bolt and tie it to a long stick or similar

This time, the weighted fluoro brickies string line is attached to a long stick or curtain rod. The string still needs to be about 8 feet long.

Step 2 – Loading, Hoisting, Positioning of Stands, and Lowering on to the Stands

Load the gyro as required. Then hoist the gyro up (ROTORS ON) high enough to enable the wheel stands to be positioned under the main wheels. Position the stands and check for stability. The gyro is then gently lowered down on to the main-wheel stands, and the wheels are then chocked in position to prevent rolling.

Step 3 – Carefully Tilting Back the Gyro

ASRA suggests keeping the hoist sling around the rotor head for safety, with the line slackened off just enough to not pull on the mast and interfere with the balancing on the main wheels.

With the assistance of helpers, the gyro is carefully tilted back until it reaches the point where it is balancing finely on the main wheels.

Step 4 – Position the string line and take 2 or 3 pictures

A helper holding the long stick with the weighted fluoro string line moves in and dangles the line as close to the centreline or long axis of the gyro as possible making sure that the line hangs precisely in line with and between the 2 main wheel axles. If the gyro had a large pod, the string should be held near the side of the pod and lined up between the 2 main wheel axles.

As before, the long axis of the gyro needs to be exactly perpendicular (90 degrees) to the camera. Obviously, because the gyro is now chocked and balancing precariously in position, this time the camera and tripod may need to be moved to line up properly. The camera should still be at the same distance from the gyro as the hang-test pictures were taken from, and – as before – the whole gyro must be visible in the photograph.

The camera operator should make a final check that the string line is precisely in line with and between the main-wheel axles, and in line with the camera. 2 or 3 pictures are then taken.

Ensuring that Your Tests are Correctly Recorded

You MUST properly record your testing process using a good digital camera.

When taking the required digital photographs, don't forget to include the reference scale on the mast as well as A4 signs showing "Full Tank" or "Empty Tank."

Plotting on the Resulting Photographs – Vertical Centre of Gravity

You now should have 2 sets of photographs - the hang test photos and the tilt-back or balance test photos. (Make sure you don't mix up full tank with empty tank pictures.

Print a few copies of each out. To quickly find out where your vertical centre of gravity is, cut out a small vertical rectangular piece of one of your tilt-back pictures showing the fluoro string line in the middle of the long axis of the rectangle and make sure there is some of the gyro structure also visible behind the string line.

Carefully position the cut-out rectangle over one of your hang test pictures and line the rectangle up so that the gyro structure showing in the rectangle blends together or matches up into the structure showing on the hang test picture. Fix or glue it in that position.

You can now draw the lines to match up as an X like shown in the diagram shown before. Congratulations! You have now plotted the vertical centre of gravity!

This process can also easily be done using a photo-editing program on a computer. In fact, the photo-editing method is the method preferred by ASRA because those images can be stored and transmitted by email.

Plotting on the Resulting Photographs – Propeller Thrust Line

If you rigged up a fluoro brickies string line to show the propeller thrust line, then it's already there! If you didn't, now is the time for you to carefully and precisely draw a line on your photograph representing where the propeller thrust line is. It must be perfectly drawn to be in line with the propeller rotational axis and exactly perpendicular (90 degrees) to the propeller blades. Draw the line long enough so that it crosses both the hang-test and the tilt-back string lines shown on the photograph.

Final Plot – Measuring the Distance Between the vertical C of G and the Thrust Line

This is where you use a magnifying glass to spot the reference scale on the side of your gyro's mast in the picture and then carefully use it to measure the distance between the vertical centre of gravity and the propeller thrust line. The reference scale is made up of alternating black and white 1-inch blocks and is 7 inches long. Use the scale to accurately measure the distance between your lines on the photograph. One-inch equals 25.4mm.

Plotting for Possible Centre of Gravity "Migration"

ASRA is very keen to determine whether vertical centre of gravity "migration" from fuel burn-off in all gyros is a cause for concern or not.

Therefore, for single seaters you are required to plot the vertical centre of gravity for these 2 conditions: -

a) EMPTY FUEL TANK

b) FULL FUEL TANK

ASRA considers this research as vital and urges that everyone undertakes these required tasks positively and carefully.

At the Finish

You will now know whether your gyroplane is Low Thrust Line (LTL); Centre Line Thrust (CLT); or, High Thrust Line (HTL) for particular fuel combinations.

And, importantly, you will be able to objectively verify your conclusions by providing your pictures as evidence.

WHAT YOU WILL ULTIMATELY HAVE TO SUBMIT TO ASRA

What precisely needs to be recorded for ASRA.

The following is a table of what results need to be photographically recorded, kept intact by you and submitted as part of the new listing process:

For single seat gyroplanes

(EMPTY FUEL TANK)

Hang Test: Empty Fuel Tank

1 an A4 sized paper print of a digital side-on photograph of the gyroplane with empty fuel tank and occupant undergoing hang test with a vertical line visible on the photograph from teeter bolt hang point;

Tilt-back Test: Rotors On with Empty Fuel Tank

2 an A4 sized paper print of a digital side-on photograph of the gyroplane with empty fuel tank and occupant undergoing tilt-back test with a vertical line visible on the photograph from a point on the frame precisely between the main wheels.

(FULL FUEL TANK)

Hang Test: Full Fuel Tank

3 an A4 sized paper print of a digital side-on photograph of the gyroplane with full fuel tank and occupant undergoing hang test with a vertical line visible on the photograph from the teeter bolt hang point;

Tilt-back Test: Rotors On with Full Fuel Tank

4 an A4 sized paper print of a digital side-on photograph of the gyroplane with full fuel tank and occupant undergoing tilt-back test with a vertical line visible on the photograph from a point on the frame precisely between the main wheels;

Two Resulting Vertical C of G Plots

5 you will also be required to provide 2 A4 size images of the resulting vertical centre of gravity plots with the intersecting hang-test and tilt-back lines clearly visible with the intersection of those two lines visible as a shallow X.

Notes

6 an A4 size sign or placard shall be visible in each hang and tilt-back digital photograph indicating "full tank" or "empty tank".

7 a vertical measuring reference strip made of printed paper 1 inch wide and 7 inches high must be stuck to the mast and visible in all the digital photographs.

8 rotor head torque tube to be locked at pitch-range mid-point for hang-testing by secure chocking at the head (locking at control stick end is absolutely prohibited).

9 hang testing is obviously done with the rotors off, and the teeter bolt MUST be supported within a hang-test hoisting block that many people already have – under no circumstances can a gyroplane be lifted or hoisted on an unsupported teeter bolt alone.

10 the usual "on wheels" listing picture is also to be submitted; and

11 an accurate statement of the current empty weight of the gyroplane in kilograms is also to be submitted.

<u>Getting Assistance</u>

For specific inquiries please firstly consult a TA in your local area, or email or telephone the President, The Head of Flight Operations (HOFO) or the Head of Airworthiness and Maintenance (HAM) via the ASRA website links.

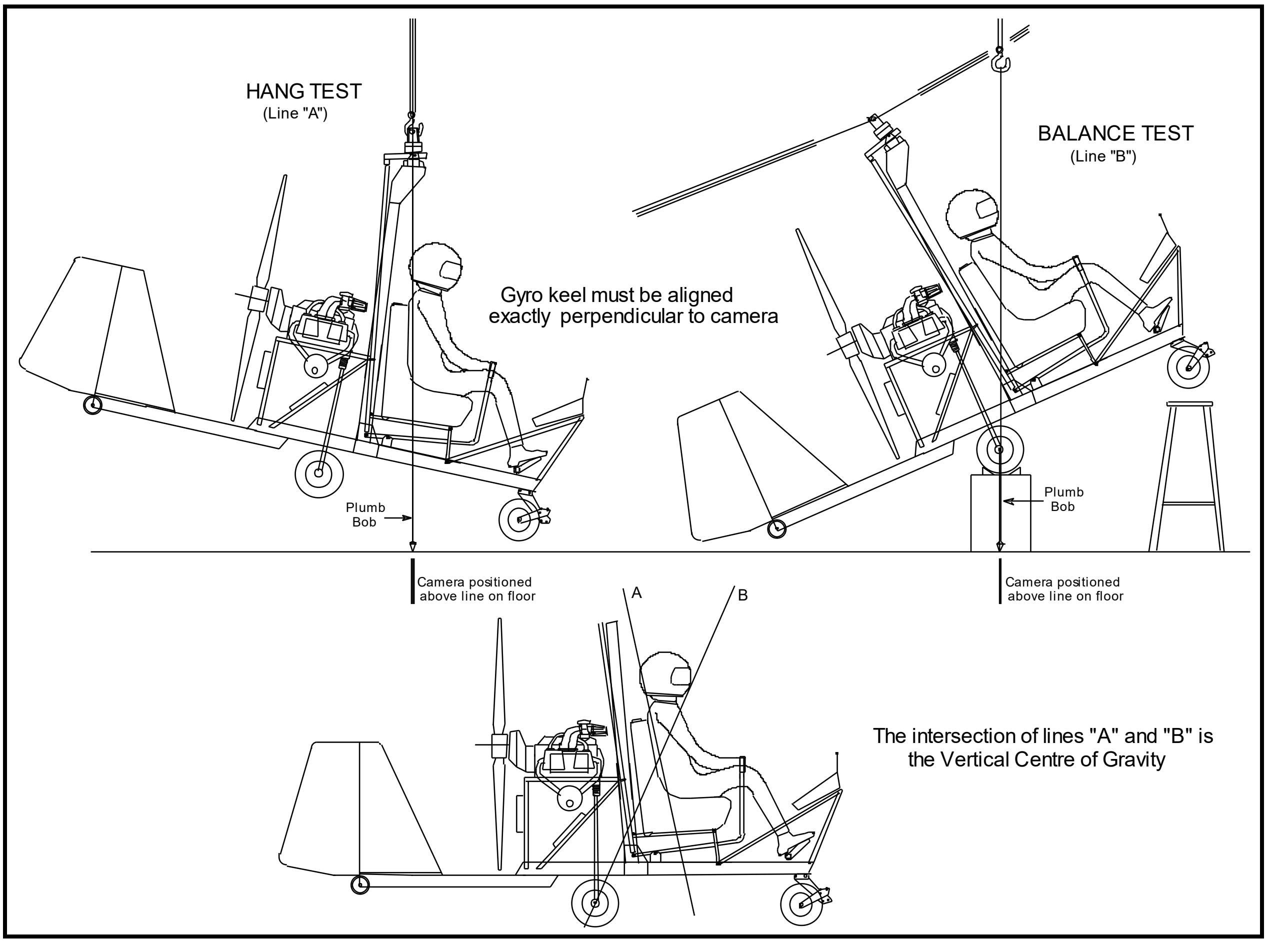


Diagram drawn and supplied by Tim McClure