

AIRWORTHINESS APPROVAL NOTE NO: 25727 Addendum 1

APPLICANT: Cyclone Airsports
AIRCRAFT TYPE: Cyclone AX2000 (Microlight)
REGISTRATION NO: G-MYER CONSTRUCTOR'S NO: CA001
DESIGN ORGANISATION: Cyclone Airsports
CERTIFICATE CATEGORY: Permit to Fly
MODIFICATION NO: AX-80
MODIFICATION TITLE: Type Approval of the Cyclone AX2000 and Approval for a Permit to Fly

1. **Introduction**

The Cyclone AX2000 is a development of the Cyclone AX-3 (approved by AAN 23042 TADS No BM45 refers) with the following changes:

- Rotax 582 powerplant with Type E Gearbox
- Ecoprop three-bladed 174/130/L/3 composite propeller
- Storage battery, solenoid, regulator
- 100% double-surface wing with APS leading edge pocket pressurisation
- Reduced area wing (15.77 sq m compared to 16.8) with modified structure
- Quantum-type mainwheels and brakes
- Lighter fuselage with miscellaneous structural changes
- AX74 main fuselage beam
- Anti-balance/trim tab
- Increased fuel tank capacity (50 litres compared to 28 litres)

This variant is introduced by Modification AX80, which defines changes from the AX3.

The AX2000 has been stressed to a maximum take-off weight of 450 kg, but the initial issue of this AAN approves the aircraft at a maximum take-off weight of 390 kg. Although the capability for aerotowing of Class 1 and Class 2 hang gliders is a feature of the AX2000, this feature is not approved by this AAN.

The Cyclone AX-3 has been previously approved by the PFA at 450 kg maximum take-off weight.

The Cyclone AX2000 is defined in TADS No BM 53 Issue 1.

Addendum 1 was raised to include the glider-towing modification.

2. Description

2.1 General

The Cyclone AX2000 is of conventional layout. It has a high keel tube running the length of the airframe to which are mounted all the major components (i.e. the engine, the wings and the empennage). It is identical in layout to the existing Cyclone AX3 and has a tricycle undercarriage arrangement. It is powered by a Rotax 582 engine.

It has a side by side seating layout with a single centrally mounted stick and two sets of rudder pedals. The aircraft is fitted with a non-structural cockpit fairing and has forward hinged removable doors. There are two fuel tanks providing a maximum capacity of 50 litres. The main fuselage beam is of steel tube wire-braced construction in accordance with Modification No AX-74, approved by AAN 25599. The main undercarriage legs are composite.

The aeroplane is generally constructed of 6261 T6 and 7075 T6 Aluminium alloy covered (on both the wings and fuselage) by "ULTRALAM" man-made fabric. This (155 gsm) material consists of a polyester substrate with a PVF film covering and is produced by GTS Flexible Materials Ltd., Bracknell.

The two spar, double-surface wing has the profile formed by battens, rather than ribs. There is an anti-balance/trim tab fitted to the aircraft. It has no flaps.

Aerotowing of Class 1 and Class 2 hang gliders is carried out by adding tug pillars to the lower surface of each wing (attached to the rear spar). The tow line is in the form of a vee-cable from each tow pillar to the main towline to the glider.

The Cyclone AX2000 is defined by Cyclone AX2000 Drawing Schedule Issue 2 dated 15 January 1997. The Aerotowing variant is defined in Cyclone AX2000 Drawing Schedule Issue 2 dated 5 Dec 1996, and is Cyclone Modification AX110.

2.2 Powerplant

The Cyclone AX2000 is powered by a Rotax 582 twin-cylinder water-cooled two-stroke engine with a capacity of 580 cc and developing 48 kW (64 HP) at 6500 rpm. The manufacturer's maximum rpm limit is 6800 rpm. The applicant has elected to placard maximum continuous power at 6200 rpm. The engine is equipped with a 3.47:1 'E' Type reduction gearbox with integral electric starter driving an Ecoprop 174/130/L/3 3-bladed ground-adjustable composite propeller of 1700 mm (67 inches) diameter with a blade angle of 25 degrees measured 535 mm from the centre of each blade. The maximum propeller speed is 1960 rpm.

2.3 Wing

The wing of the AX2000 has reduced area wing; 15.77 sq m compared to 16.8 for the AX-3. The span is reduced by 400 mm. It is a 100% double-surface wing with APS (Active Pressure System) leading edge pocket pressurisation.

2.4 Fuselage

The fuselage from the main beam aft is unchanged from the AX3 structure. The forward fuselage has been modified by incorporation of a redesigned nose leg tube and the engine torque taken by a single strut, replacing the twin long main beam-to-engine tubes of the original AX3. The front cockpit tubes are moved forwards 130 mm to facilitate easier cockpit egress. The rotational restraint provided to the main undercarriage in drag by the front cockpit tubes is maintained by two plates.

2.5 Tail Unit

The anti-balance tab is defined in drawing No 201025 and is fitted to the trailing edge of the starboard elevator.

2.6 Undercarriage

The undercarriage is unchanged from that of the AX3 fitted with AX-74 main fuselage beam, approved by AAN 25599 at a maximum weight of 390 kg, complying with BCAR Section S. The undercarriage has been subject to drop tests to show compliance with the appropriate parts of JAR-VLA at an increased weight of 450 kg.

2.7 Aerotowing Variant

Aerotowing of Class 1 and Class 2 hang gliders is carried out by adding tug pillars to the lower surface of each wing, attached to the rear spar, wire-braced to the front spar. The tow line is in the form of a vee-cable from each tow pillar to the main towline to the glider and is defined in GA drawing SW-90600. The Aerotowing variant is defined in Cyclone AX2000 Drawing Schedule Issue 2 dated 5 Dec 1996.

Two Bill Brooks-designed release hooks trail from the tug pillars. The ends of a 15m long tow bridle are attached to each hook and the single tow cable is attached to the bridle by a slip ring. The tow cable contains a parachute near the glider end which is closed under tension. The weak links consist of towing cable looped back and sewn to itself and are rated at approximately 55 kg each at the tug end and 100 kg at the glider end. The single release control operates the release hooks via two cables simultaneously through outer cables. In the event of a hang-up of one hook, the bridle cable is intended to slide through the slip ring.

3. Certification Basis

The certification basis for the AX2000 at a maximum take-off weight of 390 kg is BCAR Section S Issue 1 dated April 1995.

Statements of absolute compliance with Section S have been accepted for all except the following requirements:-

S 25 Weight Limits

S 471, 473, 474 Ground Loads

4. Investigation

Investigation was limited to areas where the Cyclone AX2000 differs from the previously approved Cyclone AX3.

4.1 Findings of Equivalent Safety

4.1.1 S 25 Weight Limits

The AX2000 has a maximum design weight of 450 kg and complies with BCAR S25(b) at 450 kg:

Empty weight include oil, coolant, electrolyte and unusable fuel (nominal)	201 kg
2 x 90 kg crew	180 kg
50 litres fuel	36 kg
Baggage	33 kg
Total	450 kg

Since the aircraft complies with S25(b) at a weight which enables 50 litres of fuel and 2 x 90 kg occupants to be carried, it has been agreed that JAR-VLA 25(a) can be used at 390 kg MTWA which provides an equivalent level of safety. The 390 kg MTWA is made up as follows:

Empty weight include oil, coolant, electrolyte and unusable fuel (nominal)	201 kg
2 x 86 kg crew*	172 kg
23.6 litres fuel**	17 kg
Total	390 kg

* Permitted by CAA letter Reference 9/23/DAI/8909/84 dated 21 June 1995.

** One hour's endurance at placarded maximum continuous rpm of 6200 rpm.

Compliance with the MTWA is the responsibility of the pilot as instructed by placards and the flight manual for the AX2000.

Loading in accordance with JAR-VLA 25(2)(ii), single pilot, full fuel and oil is:

Empty weight include oil, coolant, electrolyte and unusable fuel (nominal)	201 kg
1 x 86 kg crew	86 kg
50 litres fuel	36 kg
Baggage	33 kg
Total	323 kg

4.1.2 Undercarriage Loads and Testing

The applicant has declared compliance with JAR-VLA for the undercarriage load derivation and testing. This is accepted on the basis that the applicant has addressed in full the requirements of JAR-VLA 471 to 499 and JAR-VLA 723 to 727 in lieu of S 471 to 474 and has demonstrated compliance with these appropriate parts of JAR-VLA in toto.

4.2 Powerplant

The engine is not required to be type-certificated, but evidence has been provided to CAA that the engine/propeller combination has completed 150 hours of operation without incident, and therefore has been shown to comply with BCAR S903.

The propeller strength has been previously assessed in the approval of the Quantum 15 with the Rotax 912 engine AAN 25388), which approved the propeller at a higher speed of 2544 rpm; the propeller speed of the AX2000 is 1960 rpm.

4.3 Wing

Stress report 'Finite Element Analysis and Optimisation of AX-3 Wing Structure' Issue 2 dated 18 Oct 96 (Section 8 of Modification Submission AX-80) details the stress analysis of the modified wing based on test results of the original AX-3 wing and finite element analysis to design for a greater load of 450 kg for the reduced area wing.

A finite element model of the original AX3 wing structure was created, loaded to a level at which the actual structure failed at the equivalent of 420 kg in the 60% CP, 2.66g case with 1/3 aileron and maximum Vd stabiliser load, all factored by the ultimate/proof factor of 1.5. The critical area was found to be the inner rear spar, as demonstrated in the AX3 load test. The reduced area wing structure was re-optimised to give stresses slightly lower than for the original AX3 model.

Although no additional structural testing has been carried out, the modified wing is sufficiently similar to the original design, and the finite element modelling programme sufficiently reliable to obviate the need for re-test. The redesigned structure has been proved by cross-checking stress calculations taking into account fitting factors and non-linear beam/column instability.

4.4 Fuselage

The modified structure of the forward fuselage has been proven by load test of the engine mounting, where the 6g engine torque and download case was reacted by the fuselage in bending and torsion. The engine mounting was also tested to an upload of 4.5g, also reacted by fuselage bending. In addition, the fuselage was subjected to a stress analysis to check the capability of the fuselage to resist the up- and down-loads from the wing root fittings.

Other items subject to stress analysis (Section 8 of Modification submission AX-80), but not structural test are:

- a) Nose leg tube
- b) Cockpit floor tube
- c) Footrest tube
- d) Fuselage main beam at 450 kg (approved by AAN 25599)
- e) Forward fuselage

Structural testing was not required in these areas because of their similarity to the unmodified structure and their amenability to structural analysis.

The tests carried out were:

- a) Engine torque and download and fuselage down bending test (Section 7 of AX80 submission, report dated 29 Oct 96)
- b) Engine upload and fuselage upward bending test (Section 7 of AX80 submission, report dated 29 Oct 96)
- c) Engine side load and fuselage side bending case (Section 7 of AX80 submission, report dated 29 Oct 96)

4.5 Tail Unit

The increased tailplane loads due to the higher aircraft weight have been addressed by analysis. The new anti-balance tab was designed to withstand twice the normal operating loads exerted on it in flight at Vd without movement of the trim control. The system has been demonstrated to be irreversible by this test. Anti-balance trim tab test (Section 7 of AX80 submission, report dated 26 Apr 96) refers.

4.6 Undercarriage

The applicant has conducted undercarriage drop tests as follows:

Landing Weight 450 kg

Loads derived in accordance with JAR-VLA 471 to 499

Drop height and drop weight derived in accordance with JAR-VLA 725 and 727.

The following tests were carried out:

- (i) Limit load horizontal attitude (three-wheel landing)
- (ii) Limit load landing attitude (two-wheel landing)
- (iii) Ultimate load horizontal attitude (three-wheel landing)
- (iv) Ultimate load landing attitude (two-wheel landing)

The test procedure and results are recorded in Section 7, Appendix 11A of the applicant's submission. The Appendix numbering is consistent with the applicant's JAR-VLA submission to the PFA at 450 kg. Appendices 11, 12 and 18 of this submission address undercarriage strength and static testing and demonstrate compliance with the appropriate parts of JAR-VLA.

The limit drop tests resulted in no deformation of the undercarriage or any part of its supporting structure. Minor permanent deformation occurred as a result of the ultimate drop tests. In no case did the undercarriage fail.

4.7 Miscellaneous structural tests

- a) Trim wheel test (Section 7 of AX80 submission, report dated 12 Nov 96) in accordance with BCAR S 405.
- b) Throttle stops (Section 7 of AX80 submission, report dated 14 Nov 96) in accordance with BCAR S 405. The throttle levers are identical to the AX3, but the stop system is by nylon webbing strop, close to the point of load application.
- c) Rudder stops (Section 7 of AX80 submission, report dated 12 Nov 96). The rudder pedal system and linkage to nosewheel steering is the same as the AX3, but the AX2000 has the steering head bearing set directly into the nose leg tube and the stop design has been changed to a cable type.
- d) Battery mount (Section 7 of AX80 submission, report dated 22 Nov 96). The Rotax 582 engine can be fitted with an electric start system, the battery for which is mounted on the aircraft keel, secured by nylon webbing.

4.8 Handling and Performance

The applicant has provided evidence that the Cyclone AX2000 has been tested against the full performance and handling requirements of BCAR Section S at weights up to 450 kg, over the full centre of gravity range (see paragraph 6).

4.9 Aerotow System

Tests were carried out under the most adverse combination of side load, upload and rearward load. Load Test Reports S5 Structure Tests dated 5 Dec 96, show that the system is in accordance with BCAR Section S Paper No S885 Issue 1 dated 28 Sept 1995 (Aerotowing of hang gliders) Supplement 5. In addition, the Aerotow system was subject to a separate CAA assessment reported in paragraph 6 below. The bridle was assessed to be sufficiently long to allow the glider to be considerably out of position laterally and high before the bridle can contact the empennage of the tug.

5. Compliance with Requirements

The applicant has submitted a Compliance Checklist, Section 5 of Modification AX-80. This modification has been assessed against the requirements of BCAR Section S by the manufacturer. The CAA have examined this manufacturer's submission and is satisfied that the AX2000 complies with the requirements as detailed in paragraph (3) with the equivalent safety findings noted in paragraph (4) above.

The Aerotowing variant was found to comply with the requirements of BCAR Section S Paper No S885 Issue 1 dated 28 Sept 1995 (Aerotowing of hang gliders) Supplement 5.

6. Flight Test

Applicant's Flight Test Schedule dated 13 Nov 96 (Section 9 of Modification submission AX-80) details the flight testing carried out on the AX2000 at weights up to 450 kg against the certification basis.

Flight Test Report dated 14 Nov 95 (Section 9 of Modification submission AX-80) details the testing carried out to investigate the failure of one rudder centralising spring in the rudder circuit.

A CAA handling assessment has been carried out and reported in FTR/10036P. The performance and handling was acceptable to CAA. In addition, the Aerotowing variant was assessed by Mr W A Bevan and reported in internal CAA Memorandum dated 17 Jan 1997. Its handling and performance in this configuration were satisfactory.

7. Owner's Manual

Cyclone AX2000 Owners Manual Issue 1 contains the information required by BCAR Section S from both the Pilot's Handbook and the Maintenance Manual. This owner's manual also contains the aerotowing supplement.

8. Noise

Noise certification standards described in BCAR Section N Issue 5 are applicable to all microlights registered in the UK after 1 Apr 84. Accordingly Noise Type Certificate No. 141M has been issued to the Cyclone AX2000 at 390 kg. Each individual aircraft shall comply with the noise regulations.

9. Limitations

As detailed in CAA TADS BM 53 Issue 1 plus the additional placard:

"With two crew, maximum fuel x litres"

Where $x = 23.6 + (201 - \text{empty weight (kg)})/0.718$

This placard is to be completed by Cyclone Airsports.

10. Maintenance

Cyclone AX2000 Owners Manual Issue 1 Section 2 contains the information required by BCAR Section S.

11. Approval

The Cyclone AX2000 microlight aeroplane is type-approved at 390 kg MTWA (TADS BM 53 Issue 2 refers). This aircraft, G-MYER, and any aircraft conforming to the type design is eligible for the issue of a Permit to Fly provided that it is operated in accordance with the Owner's Manual referred to in Paragraph 7 and maintained to the provisions of this manual.

R J Hardy

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For the Civil Aviation Authority

Date 3 April 1997