Guidelines for the Noise Measurement of Homebuilt Aircraft

ANCAT Ad Hoc Group on Noise Measurement of Homebuilt Aircraft
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Foreword

This document prepared by the European Civil Aviation Conference (ECAC) provides guidelines for the noise measurement of homebuilt aircraft. These guidelines arise from the best practices collected within ECAC Member States. They are not intended to be prescriptive. Nonetheless, their use should promote mutual recognition of noise measurement methods and so facilitate movements of homebuilt aircraft within ECAC Member States.

Introduction: Applicability and Definition

1. Applicability

Homebuilt aircraft fall under Annex II of Regulation (CE) No 216/2008, and so their environmental design characteristics are not subject to European law. Some ECAC Member States have developed their own noise regulation and noise measurement procedure based on the provisions of ICAO Annex 16, Volume I. It is recommended that as far as possible the provisions of ICAO Annex 16, Volume I, Chapters 6, 10 and 11 are applied.

Part 1 of this document contains guidelines for the noise measurement of homebuilt propeller-driven aeroplanes not exceeding 8 618 kg maximum take-off mass.

Part 2 contains guidelines for the noise measurement of homebuilt rotorcraft not exceeding 3 175 kg maximum take-off mass.

2. Homebuilt Aircraft Definition

In accordance with Annex II of Regulation (CE) No 216/2008, the definition of a homebuilt aircraft is the following:

Aircraft of which at least 51% is built by an amateur, or a non-profit making association of amateurs, for their own purposes and without any commercial objective.

Note - This definition may correspond to different aircraft categories.

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Part 1

Guidelines for the Noise Measurement of Homebuilt Propeller-Driven Aeroplanes Not Exceeding 8 618 kg Maximum Take-Off Mass

ICAO Annex 16, Chapter 6 and Chapter 10, contain appropriate noise measurement procedures for homebuilt propeller-driven aeroplanes. However, the noise emanating from the aircraft differs according to the noise measurement methods described in either Chapter. Chapter 6 reveals the aircraft's noise level in cruise configuration, while Chapter 10 provides the aircraft's noise level in climb configuration after take-off.

1. Homebuilt Propeller-Driven Aeroplanes Measured under Chapter 6 of Annex 16

1.1 Performance correction

Section 4.2.3 of Appendix 3 of the Annex specifies that a performance correction is added algebraically to the measured value to credit higher aeroplanes take-off and flight performances based on their ability to climb at a steeper angle and to fly the traffic pattern at a lower power setting. Also, this correction penalises aeroplanes with limited flight performance capability which results in lower rates of climb and higher power settings in the traffic pattern.

The performance correction is calculated as follows:

$$\Delta dB = 49.6 - 20\log\left[(3500 - D_{15})\frac{R/C}{V_y} + 15\right]$$

Where:

- D_{15} is the sea level, ISA take-off distance in metres to a height of 15 m at the maximum certificated take-off mass and maximum certificated take-off power;
- R/C is the sea level, ISA best rate of climb (m/s) at the maximum certificated take-off mass and the maximum power and engine speed; and
- V_y is the speed (m/s) for the best rate of climb.

The performance figures can normally be found in the performance section of an AFM or pilot's operating handbook.

As prescribed in section 4.2.3 of Appendix 3, when the take-off distance D_{15} is not certificated, the figure of 610 m for single-engined aeroplanes and 825 m for multi-engined aeroplanes is used. However, if either the best rate of climb R/C or the climb speeds are not certificated, the performance correction should not be applied.

Note – Homebuilt aircraft are generally light aircraft with high take-off and climb performances. For those aircraft the absence of performance correction must lead to a conservative noise level.

1.2 Take-off and climb performances

Although the components of an individual homebuilt aeroplane may conform to those of a homebuilt aeroplane type, the performance data (D_{15}, R/C, and V_y) of both aircraft may prove to be different. Thus, it may be necessary to evaluate the performance of each individual aircraft. If an individual aircraft's noise level gives rise to deliver a noise certificate, its performance figures should be approved by the certifying authority.

1.3 Homebuilt aircraft with high propeller speed

The Chapter 6 noise measurement procedure is suitable to reveal the maximum noise level emitted by the aircraft. This procedure is especially appropriate for some homebuilt aeroplanes fitted with an engine driving the propeller at higher speed than usual, up to 3300 rpm. It has been identified that the noise level of this aircraft type may significantly be below the Chapter 10 maximum permitted noise level while it may drastically exceed the Chapter 6 maximum permitted noise level.

For these aircraft with a propeller speed typically beyond 2800 rpm, the maximum propeller speed can be limited in accordance to Chapter 6 provisions. The limitation should be quoted in the pilot's operating handbook and on the RPM indicator in the form of an indelible mark.

1.3.1 Example of RPM limitation

Technical characteristics

- MTOM= 750 kg
- Maximum RPM= 3100 rpm
- D_{15}= 500 m
- V_y= 41.7 m/s
- R/C= 4.07 m/s

Measured and corrected noise level

Three series of overflights are performed: one series at maximum continuous power (NMCP) and two series at reduced power.

	No	HT (m)	RPM (rpm)	(L_{Amax}) TEST (dBA)	(L_{Amax}) REF (dBA)
1XX	101	300.0	2985	70.5	72.4
	102	294.3	3045	71.1	71.0
	103	300.7	2973	69.6	71.8
	104	300.8	3115	72.4	72.5
	105	303.2	3079	71.7	71.8
	106	296.5	3115	73.3	73.2
2XX	201	308.8	2920	67.5	67.8
	202	295.9	2873	67.5	67.3
	203	307.9	2850	66.4	66.6
	204	297.7	2900	65.2	65.1
3XX	301	294.3	2550	62.3	63.0
	302	288.3	2685	62.5	62.1
	303	298.7	2738	63.7	63.7
	304	288.5	2610	60.4	60.0

Where:
- H_T is the height of the aeroplane when passing over the microphone;
- (L_{Amax}) TEST is the test day noise level;
- (L_{Amax}) REF is the noise level in reference conditions.

$$(L_{A\max})REF = (L_{A\max})TEST + \Delta 1 + \Delta 2 + \Delta 3$$

- Δ1 is the adjustment for noise path length;
- Δ2 is the adjustment for helical tip Mach number; and
- Δ3 is the adjustment for engine power.

Performance correction and level certified

The performance correction is calculated as follows:

$$\Delta dB = 49.6 - 20\log\left[(3500 - 500)\frac{4.07}{41.7} + 15\right]$$

$$\Delta dB = -0.17dBA$$

For each series of tests, the aeroplane noise level (LA_{Max}) is the sum of the arithmetic average of the (L_{Amax}) REF values and the performance correction.

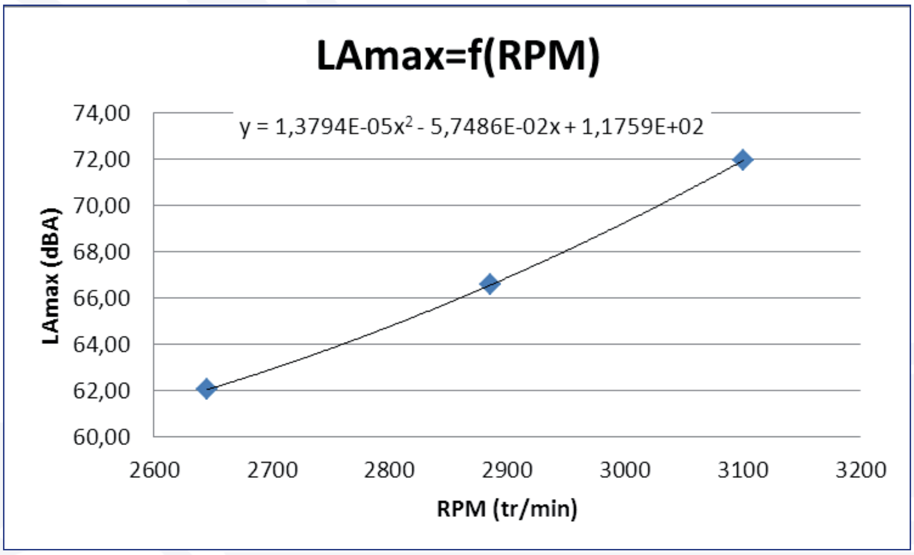
RPM associated with the series 2 and 3 are the average RPM of these series.

No	RPM (rpm)	L_{Amax} (dBA)
1XX	3100	71.9
2XX	2886	66.6
3XX	2646	62.0

The maximum permitted noise level for this example is 70 dB(A) (MTOM = 750 kg).

The first series is performed with the propeller speed corresponding to the maximum continuous power. The corresponding noise level to be certified exceeds the maximum permitted noise level by 1.9 dB(A).

RPM limitation



Equation of the curve $L_{A\max} = f(RPM)$

$$L_{A\max} = 1.38 \times 10^{-5} RPM^2 - 5.75 \times 10^{-2} RPM + 117.59$$

- Limitation

The engine RPM is limited by steps of 50 rpm until the noise level be below or equal to 70 dBA.

For this example, **LAmax = 69.3 dBA with RPM limited to 3000 rpm**.

Note – 50 rpm is the marking resolution of the engine speed indicator.

2. HOMEBUILT PROPELLER-DRIVEN AEROPLANES MEASURED UNDER CHAPTER 10 OF ANNEX 16

2.1 REFERENCE HEIGHT

According to the provisions of Chapter 10 and Appendix 6, the take-off reference profile is used to compute the height of the aeroplane passing over the microphone (see Figure 1).

The reference flyover height is defined according to the take-off reference flight path at a point 2 500 m (8 202 ft) from the start-of-roll for an aeroplane taking off from a paved, level runway under the following conditions:

- sea level atmospheric pressure of 1 013.25 hPa;
- ambient air temperature of 15°C (i.e. ISA);
- relative humidity of 70 per cent; and
- zero wind.

This height can be defined in terms of the approved take-off and climb performance figures for the conditions described above as follows:

$$H_R = \left(2500 - D_{15}\right) \times \tan\left[\sin^{-1}\left(\frac{RC}{V_y}\right)\right] + 15$$

Where:
- D_{15} is the sea level, ISA take-off distance in metres to a height of 15 m at the maximum certificated take-off mass and maximum certificated take-off power;
- RC is the sea level, ISA best rate of climb (m/s) at the maximum certificated take-off mass and the maximum power and engine speed that can be continuously delivered by the engine(s) during this second phase; and
- V_y is the speed (m/s) for the best rate of climb.

The performance figures can normally be found in the performance section of an AFM or pilot's operating handbook.

Some homebuilt aeroplanes are light aircraft with high take-off and climb performances leading to a high reference height. Determination of the aircraft height by the photographic scaling techniques may prove difficult and inaccurate due to the size of the aircraft on the photography. In addition, high frequencies of the aircraft's noise may significantly be attenuated due to atmospheric absorption and spherical spreading. As a consequence, the whole aircraft's spectral energy is not measured on the ground and the aircraft noise level may be below the 10 dB threshold above the background noise.

Section 4.4.4 of Appendix 6 provides that a take-off measurement point nearer to the start of roll be used and the results adjusted to the reference measurement point by an approved method. Some ECAC Member States limit the reference height. Others fix an arbitrary height.

2.1.1 Example of limited test height

Take-off and climb performances for reference height determination

- D_{15}= 228 m
- V_y=33.3 m/s
- RC= 8.63 m/s

Reference height calculation

$$H_R = (2500 - 228) \times \tan\left[\sin^{-1}\left(\frac{8.63}{33.3}\right)\right] + 15$$

HR=624.6 m

Test height

The noise flight test consists of a series of overflights. The target height, when the aeroplane passes directly over the microphone, should be the reference height.

For this example, the target is limited to 420 metres.

Corrected noise level without height adjustment

No	HT (m)	(L_{Amax}) HT (dBA)
1	422.6	65.5
2	417.1	65.3
3	424.6	65.2
4	401.9	65.7
5	407.0	64.7
6	411.9	65.6

Where:
- H_T is the height of the aeroplane when passing over the microphone;
- (L_{Amax}) H_T is the aeroplane noise level in reference conditions without height adjustment Δ1.

$$(L_{A\max})H_T = (L_{A\max})TEST + \Delta(M) + \Delta 2 + \Delta 3$$

- (L_{Amax}) is the test day noise level;
- Δ(M) is the adjustment for the change in atmospheric absorption;
- Δ2 is the adjustment for helical tip Mach number; and
- Δ3 is the adjustment for engine power.

Reference noise level

The reference noise level (L_{Amax}) REF is obtained by adding an increment to (L_{Amax}) HT

$$(L_{A\max})REF = (L_{A\max})H_T + 22\log\left(\frac{H_T}{H_R}\right)$$

Where:
- H_T is the height of the aeroplane when passing over the noise measurement point; and
- H_R is the reference height.

No	(L_{AMAX}) HT (dBA)	$22\log\left(\frac{H_T}{H_R}\right)$	(L_{Amax}) REF (dBA)
1	65.5	-3.73	61.8
2	65.3	-3.86	61.4
3	65.2	-3.69	61.5
4	65.7	-4.21	61.5
5	64.7	-4.09	60.6
6	65.6	-3.98	61.6

Note - For this example the meteorological conditions are within the window specified in Appendix 6, Figure A6-2 of Annex 16.

The aeroplane noise level is the arithmetic average of the (L_{Amax}) REF values:

$$L_{Amax} = 61.4 \text{ dB(A)}$$

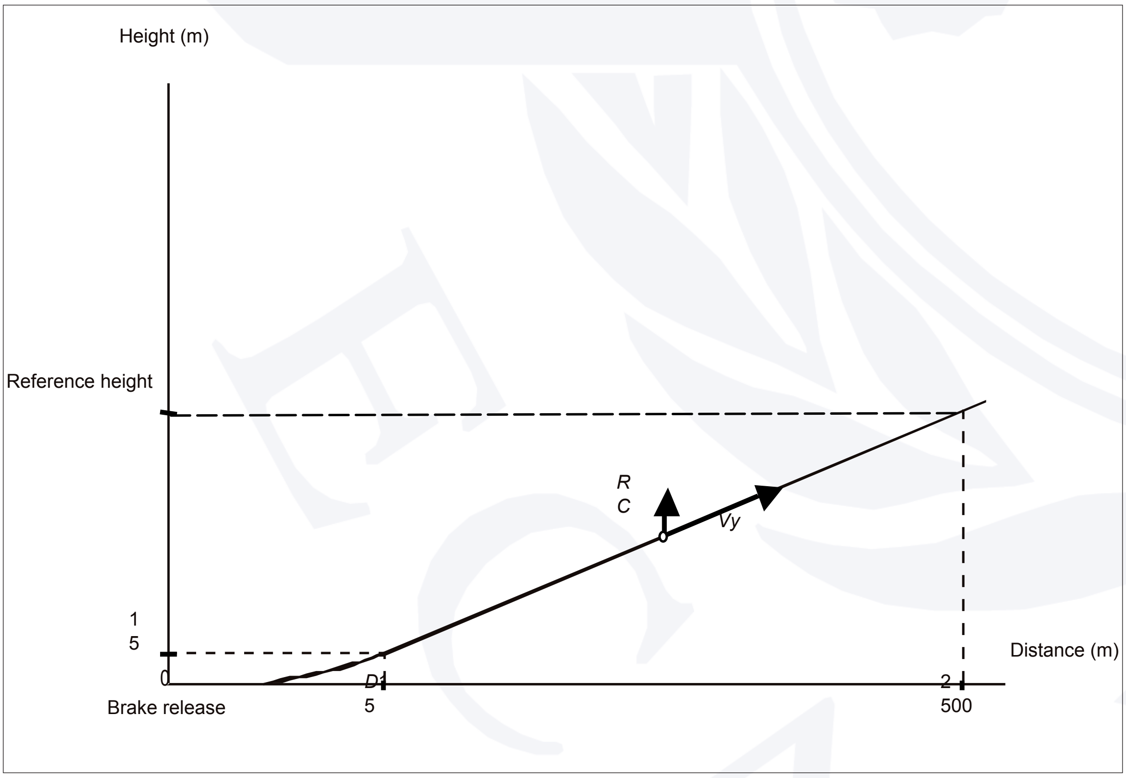


Figure 1. Take-Off Reference Profile

2.2 Approbation of take-off and climb performances

The measured noise level on ground results notably from the acoustic energy emitted by the aircraft and the reference height. If the aircraft's measured noise level is certified, take-off and climb performance figures should be approved by the certificating authority.

Although the components of an individual homebuilt aeroplane may conform to those of a homebuilt aeroplane type, the performance data (D_{15}, RC, and V_y) may prove to be different. It may be necessary to evaluate the performance of each individual aircraft. If an individual aircraft's noise level gives rise to deliver a noise certificate, its performance figures should be approved by the certification authority.

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Part 2

Guidelines for the Noise Measurement of Homebuilt Rotorcraft Not Exceeding 3 175 kg Maximum Take-Off Mass

1. Homebuilt Propeller-Driven Aeroplanes Measured under Chapter 11 of Annex 16

1.1 Approbation of the airspeed

Chapter 11 (11.5.2.1) of Annex 16 requires that a speed of 0.9 VH or 0.9 VNE or 0.45 VH + 120 km/h (65 kt) or 0.45 VNE + 120 km/h (65 kt), whichever is the least, shall be maintained throughout the overflight procedure.

Although the components of an individual rotorcraft may conform to those of a homebuilt rotorcraft type, the speeds VH and VNE may prove to be different. It may be necessary to evaluate the speeds of each individual aircraft. If an individual aircraft's noise level gives rise to deliver a noise certificate, its speeds values should be approved by the certification authority.

1.2 Aircraft stability throughout the overflight procedure

Homebuilt rotorcraft are usually light aircraft with modest piloting equipments. It may be difficult for the pilot to maintain both airspeed and rotor rpm within the tolerances prescribed in Chapter 11. In that case it is deemed appropriate to try and maintain only the airspeed in order to reach the best possible aircraft stability throughout the overflight procedure.

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