



Date : 2023/07/09 التاريخ :

Ref : 2023/096/SUPDT-R/41 الإشارة :

All KCASR Stakeholders and Users

Sub.: Regulatory Circular No. 2023-05.
Revision Number 3 to Kuwait Civil Aviation Safety Regulations - KCASR 16 - ENVIRONMENTAL PROTECTION VOLUME - I.

Dear Sir,

Please find enclosed herewith the regulatory circular No. 2023-05 regarding the issuance of KCASR 16 - ENVIRONMENTAL PROTECTION VOLUME - I Rev. 3. This is for your information and distribution to all concerned departments.


Up to date KCASR Parts are published on the DGCA/ASD website (<https://kcasr.dgca.gov.kw>).

If required, the DGCA/Aviation Safety Department personnel are available to answer your questions on the interpretation and intended implementation of the proposed amendments.

KCASR 16 - ENVIRONMENTAL PROTECTION VOLUME - I Rev. 3 will be in effect from 01/Jan/2024.

Yours Sincerely,

President of Civil Aviation.


Engr. Emad F. Al-Jelwi
Deputy Director General for Aviation Safety
Air Security & Transport Civil Aviation
Assistant Undersecretary

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Date : 2023/07/09

التاريخ :

الإشارة : 2023/095/SUPDT-R/41 Ref :

REGULATORY CIRCULAR (NO. 2023-05)

Subject:

Notice of Amendment to Kuwait Civil Aviation Safety Regulations KCASR (issue 4).

Purpose:

The purpose of this Regulatory Circular No. **2023-05** is to Amend KCASR 16 - ENVIRONMENTAL PROTECTION VOLUME - I (issue 4) .

This Regulatory Circular No. **2023-05** is based on (NPA) No. 2023-02 dated on 17/May/2023

Revisions:

This amendment will be included in revision **(03)** of KCASR 16 - ENVIRONMENTAL PROTECTION VOLUME - I.

Regulatory Requirements:

This amendment shall apply to the following Organizations approved by the Directorate General of Civil Aviation (DGCA) or authorized to operate within the State of Kuwait:

1. Approved Maintenance Organizations (AMO) Holders;
2. Air Navigation Service Providers;
3. Air Operator Certificate (AOC) & Private Operator Certificate (POC) Holders;
4. Airport Operators;
5. Ground Handling Service Providers;
6. Flying Training Organizations;
7. All users of KCASRs.

Effective Date:

This new revision will be in effect from 01/Jan/2024.

Required Action:

All users of KCASR are required to comply with the provisions contained within this amendment from the effective date **01/Jan/2024**.

President of Civil Aviation


Engr. Emad F. Al-Jelwi
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Civil Aviation
دولة الكويت - State of Kuwait

Kuwait Civil Aviation Safety Regulations


KCASR 16 – ENVIRONMENTAL PROTECTION

VOLUME – I

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Control of this Document

DC.1 Introduction

DC.1.1 Pursuant to Law No (30) of the year 1960 and subsequent Ministerial Decisions No (3) of the year 1986, No (18) of the year 1990, and No (18) of the year 1996, based upon that Law, the President of the Kuwait Directorate General of Civil Aviation is empowered to adopt and amend Kuwait Civil Aviation Safety Regulations. In accordance herewith, the following Regulation is hereby established for compliance by all persons concerned. This regulation shall be known as KCASR 16, Volume I – Environmental Protection and any reference to this title shall mean referring to these regulations governing the basic requirements to be met for civil aviation in the State of Kuwait.

DC.2 Authority for this Requirement

DC.2.1 This KCASR 16, Volume I – Environmental Protection is issued on the authority of the President of the Kuwait Directorate General of Civil Aviation.

DC.3 Applicability

DC.3.1 This KCASR 16, Volume I – Environmental Protection is applicable to the aviation industry of State of Kuwait.

DC.4 Scope

DC.4.1 KCASR 16, Volume I – Environmental Protection contains the basic regulations to be met for civil aviation in State of Kuwait, and shows compliance with ICAO Annexes. The regulations are separated into the following civil aviation safety regulations with cross references where applicable.

KCASR 0 – Basic Regulation


KCASR 1 – Personnel Licensing

KCASR 2 – Rules of the Air

KCASR 3 – Meteorological Service for International Air Navigation

KCASR 4 – Aeronautical Charts

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KCASR 5 – Units of Measurement

KCASR 6 – Operation of Aircraft

KCASR 7 – Aircraft Registration and Cancellation

KCASR 8 – Airworthiness of Aircraft and Continuous Airworthiness

KCASR 9 – Facilitation

KCASR 10 – Aeronautical Telecommunications

KCASR 11 – Air Traffic Services

KCASR 12 – Search and Rescue

KCASR 13 – Aircraft Accident and Incident Investigation

KCASR 14 – Volume I - Aerodromes

KCASR 14 – Volume II – Aerodromes – Heliports

KCASR 14 – Volume III – Gropund Handling Operations (GHO)

KCASR 15 – Aeronautical Information Services

KCASR 16 – Environmental Protection

KCASR 18 – Dangerous Goods

KCASR 17 – Aviation Security

KCASR 19 – Safety Management


KCASR 22 – Unmanned Aircraft Systems

KCASR 23 – Light Sport Aircraft

KCASR 25 – Special Aviation Regulations

KCASR 26 – Enforcement and Sanctions

KCASR 27 – Charges and Fees

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DC.5 Definitions

DC.5.1 Terms not defined within this document shall have the meaning given to them in the relevant legal instruments or international legal instruments in which they appear, especially as they appear in attachment 1 to KCASR 00.

PART I. DEFINITIONS, NOMENCLATURE: SYMBOLS AND UNITS

Aeroplane. A power-driven heavier-than-air aircraft, deriving its lift in flight chiefly from aerodynamic reactions on surfaces which remain fixed under given conditions of flight.

Aircraft. Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth’s surface.

Associated aircraft systems. Those aircraft systems drawing electrical/pneumatic power from an auxiliary power unit during ground operations.

Auxiliary power-unit (APU). A self-contained power-unit on an aircraft providing electrical/pneumatic power to aircraft systems during ground operations.

Bypass ratio. The ratio of the air mass flow through the bypass ducts of a gas turbine engine to the air mass flow through the combustion chambers calculated at maximum thrust when the engine is stationary in an international standard atmosphere at sea level.

Derived version of a helicopter. A helicopter which, from the point of view of airworthiness, is similar to the noise certificated prototype but incorporates changes in type design which may affect its noise characteristics adversely.

Note 1.- A helicopter that is based on an existing prototype but which is considered by the certifying authority to be a new type design for airworthiness purposes is considered as a derived version for noise purposes if the noise source characteristics are judged by the certifying authority to be the same as the prototype.

Note 2.- “Adversely” refers to an increase of more than 0.30 EPNdB in any one of the noise certification levels for helicopters certificated according to Chapter 8 and 0.30 dB(A) in the certification level for helicopters certificated according to Chapter 11.

Derived version of an aeroplane. An aeroplane which, from the point of view of airworthiness, is similar to the noise certificated prototype but incorporates changes in type design which may affect its noise characteristics adversely.

Note 1.- Where the certifying authority finds that the proposed change in design, configuration, power or mass is so extensive that a substantially new investigation of compliance with the applicable airworthiness regulations is required, the aeroplane is generally considered to be a new type design rather than a derived version.

Note 2.- “Adversely” refers to an increase of more than 0.10 dB in any one of the noise certification levels unless the cumulative effects of changes in type design are tracked by an approved procedure in which case “adversely” refers to a cumulative increase in the noise level in any one of the noise certification levels of more than 0.30 dB or the margin of compliance, whichever is smaller.

External equipment (helicopter). Any instrument, mechanism, part, apparatus, appurtenance, or accessory that is attached to or extends from the helicopter exterior but is not used nor is intended to be used for operating or controlling a helicopter in flight and is not part of an airframe or engine.

Helicopter. A heavier-than-air aircraft supported in flight chiefly by the reactions of the air on

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one or more power-driven rotors on substantially vertical axes.

Human performance. Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Powered-lift. A heavier-than-air aircraft capable of vertical take-off, vertical landing, and low-speed flight, which depends principally on engine-driven lift devices or engine thrust for the lift during these flight regimes and on non-rotating aerofoil(s) for lift during horizontal flight.

Recertification. Certification of an aircraft with or without a revision to its certification noise levels, to a Standard different to that to which it was originally certificated.

Self-sustaining powered sailplane. A powered aeroplane with available engine power which allows it to maintain level flight but not to take off under its own power.

State of Design. The State having jurisdiction over the organization responsible for the type design.

State of Registry. The State on whose register the aircraft is entered.

Subsonic aeroplane. An aeroplane incapable of sustaining level flight at speeds exceeding flight Mach number of 1.

Tilt-rotor. A powered-lift capable of vertical take-off, vertical landing, and sustained low-speed flight, which depends principally on engine-driven rotors mounted on tiltable nacelles for the lift during these flight regimes and on non-rotating aerofoil(s) for lift during high-speed flight.

Type Certificate. A document issued by a Contracting State to define the design of an aircraft type and to certify that this design meets the appropriate airworthiness requirements of that State.

Note. In some Contracting States a document equivalent to a Type Certificate may be issued for an engine or propeller type.

NOMENCLATURE: SYMBOLS AND UNITS

Note. Many of the following definitions and symbols are specific to aircraft noise certification. Some of the definitions and symbols may also apply to purposes beyond aircraft noise certification.

1.1 Velocity

Symbol	Unit	Meaning
C_R	m/s	Reference speed of sound. Speed of sound at a reference temperature condition (25°C).
C_{HR}	m/s	Reference speed of sound at the altitude of the aeroplane. The reference speed of sound corresponding to the ambient temperature – assuming a lapse rate of 0.65°C per 100 m – for a standard day at the aeroplane reference height above mean sea level.
M_{ATR}	-	Helicopter rotor reference advancing blade tip Mach number. The sum of the reference rotor rotational tip speed and the reference speed of the helicopter, divided by the reference speed of sound.
M_H	-	Propeller helical tip Mach number. The square root of the sum of the square of the propeller test rotational tip speed and the square of the test airspeed of the aeroplane, divided by the test speed of sound.
M_{HR}	-	Propeller reference helical tip Mach number. The square root of the sum of the square of the propeller reference rotational tip speed and the square of the reference speed of the aeroplane, divided by the reference speed of sound
Best R/C	m/s	Best rate of climb. The certificated maximum take-off rate of climb at the maximum power setting and engine speed.
V_{AR}	m/s	Adjusted reference speed. On a non-standard test day, the helicopter reference speed adjusted to achieve the same advancing tip Mach number as the reference speed at reference conditions.
V_{CON}	m/s	Maximum airspeed in conversion mode. The never-exceed airspeed of a tilt-rotor when in conversion mode.

Symbol	Unit	Meaning
V_G	m/s	Ground speed. The aircraft velocity relative to the ground.
V_{GR}	m/s	Reference ground speed. The aircraft true velocity relative to the ground in the direction of the ground track under reference conditions. V_{GR} is the horizontal component of the reference aircraft speed V_R .
V_H	m/s	Maximum airspeed in level flight. The maximum airspeed of a helicopter in level flight when operating at maximum continuous power.
V_{MCP}	m/s	Maximum airspeed in level flight. The maximum airspeed of a tilt-rotor in level flight when operating in aeroplane mode at maximum continuous power.
V_{MO}	m/s	Maximum operating airspeed. The maximum operating limit airspeed of a tiltrotor that may not be deliberately exceeded.
V_{NE}	m/s	Never-exceed airspeed. The maximum operating limit airspeed that may not be deliberately exceeded.
V_R	m/s	Reference speed. The aircraft true velocity at reference conditions in the direction of the reference flight path. <i>Note. This symbol should not be confused with the symbol commonly used for aeroplane take-off rotation speed.</i>
V_{REF}	m/s	Reference landing airspeed. The speed of the aeroplane, in a specific landing configuration, at the point where it descends through the landing screen height, in the determination of the landing distance for manual landings.
V_S	m/s	Stalling airspeed. The minimum steady airspeed in the landing configuration.
V_{tip}	m/s	Tip speed. The rotational speed of a rotor or propeller tip at test conditions, excluding the aircraft velocity component.
V_{tipR}	m/s	Reference tip speed. The rotational speed of a rotor or propeller tip at reference conditions, excluding the aircraft velocity component.

Symbol	Unit	Meaning
V_Y	m/s	Speed for best rate of climb. The test airspeed for best take-off rate of climb.
V_2	m/s	Take-off safety speed. The minimum airspeed for a safe take-off.

1.2 Time

Symbol	Unit	Meaning
t_0	s	Reference duration. The length of time used as a reference in the integration equation for computing EPNL, where $t_0 = 10$ s.
t_R	s	Reference reception time. The reference time of reception calculated from time of reference aircraft position and distance between aircraft and microphone used in the integrated procedure.
Δt	s	Time increment. The equal time increment between one-third octave band spectra, where $\Delta t = 0.5$ s.
δt_R	s	Reference time increment. The effective duration of a time increment between reference reception times associated with PNLT points used in the integrated method.

1.3 Indices

Symbol	Unit	Meaning
i	-	Frequency band index. The numerical indicator that denotes any one of the 24 one-third octave bands with nominal geometric mean frequencies from 50 to 10 000 Hz.
k	-	Time increment index. The numerical indicator that denotes any one of the 0.5 second spectra in a noise time history. For the integrated method, the adjusted time increment associated with each value of k will likely vary from the original 0.5 second time increment when projected to reference conditions.
k_F	-	First time increment identifier. Index of the first 10 dB-down point in the discrete measured PNLTM time history
k_{FR}	-	Reference first time increment identifier. Index of the first 10 dB-down point in the discrete PNLTM time history for the integrated method.
k_L	-	Last time increment identifier. Index of the last 10 dB-down point in the discrete measured PNLTM time history
k_{LR}	-	Reference last time increment identifier. Index of the last 10 dB-down point in the discrete PNLTM time history for the integrated method.
k_M	-	Maximum PNLTM time increment index. Time increment index of PNLTM
t	s	Elapsed time. The length of time measured from a reference zero.
t_1	s	Time of first 10 dB-down point. The time of the first 10 dB-down point in a continuous function of time. (See k_F .)
t_2	s	Time of last 10 dB-down point. The time of the last 10 dB-down point in a continuous function of time. (See k_L .)

1.4 Noise metrics

Symbol	Unit	Meaning
EPNL	EPNdB	Effective perceived noise level. A single-number evaluator for an aircraft pass-by, accounting for the subjective effects of aircraft noise on human beings, consisting of an integration over the noise duration of the perceived noise level (PNL) adjusted for spectral irregularities (PNLT), normalized to a reference duration of 10 seconds. (See Appendix 2, Section 4.1 for specifications.)
EPNL _A	EPNdB	<i>Approach EPNL.</i> Effective perceived noise level at the aeroplane approach reference measurement points.
EPNL _F	EPNdB	<i>Flyover EPNL.</i> Effective perceived noise level at the aeroplane flyover reference measurement points.
EPNL _L	EPNdB	<i>Lateral EPNL.</i> Effective perceived noise level at the aeroplane lateral reference measurement points
L _{AE}	dB(A)	<i>Sound exposure level (SEL).</i> A single event noise level for an aircraft pass-by, consisting of an integration over the noise duration of the A-weighted sound level dB(A), normalized to a reference duration of 1 second. (See Appendix 4, Section 3 for specifications.)
L _{AS}	dB(A)	<i>Slow A-weighted sound level.</i> Sound level with frequency weighting A and time weighting S for a specified instance in time.
L _{ASmax}	dB(A)	<i>Maximum slow A-weighted sound level.</i> The maximum value of L _{AS} over a specified time interval.
L _{ASmaxR}	dB(A)	<i>Reference maximum slow A-weighted sound level.</i> The maximum value of L _{AS} over a specified time interval corrected to reference conditions.
LIMIT _A	EPNdB	<i>Approach EPNL limit.</i> The maximum permitted noise level at the aeroplane approach reference measurement points.
LIMIT _F	EPNdB	<i>Flyover EPNL limit.</i> The maximum permitted noise level at the aeroplane flyover reference measurement points.

Symbol	Unit	Meaning
LIMIT _L	EPNdB	<i>Lateral EPNL limit.</i> The maximum permitted noise level at the aeroplane lateral reference measurement points
<i>n</i>	noy	<i>Perceived noisiness.</i> The perceived noisiness of a one-third octave band sound pressure level in a given spectrum.
<i>N</i>	noy	<i>Total perceived noisiness.</i> The total perceived noisiness of a given spectrum calculated from the 24 values of <i>n</i> .
PNL	PNdB	<i>Perceived noise level.</i> A perception-based noise evaluator representing the subjective effects of broadband noise received at a given point in time during an aircraft pass-by. It is the noise level empirically determined to be equally as noisy as a 1 kHz one-third octave band sample of random noise. (See Appendix 2, Section 4.2 for specifications.)
PNLT	TPNdB	<i>Tone-corrected perceived noise level.</i> The value of the PNL of a given spectrum adjusted for spectral irregularities.
PNLT _R	TPNdB	<i>Reference tone-corrected perceived noise level.</i> The value of PNLT adjusted to reference conditions.
PNLTM	TPNdB	<i>Maximum tone-corrected perceived noise level.</i> The maximum value of PNLT in a specified time history, adjusted for the bandsharing adjustment Δ_B .
PNLTM _R	TPNdB	<i>Reference maximum tone-corrected perceived noise level.</i> The maximum value of PNLTR in a specified time history, adjusted for the bandsharing adjustment Δ_B in the simplified method and Δ_{BR} in the integrated method
SPL	dB	<i>Sound pressure level.</i> The level of sound, relative to the reference level of 20 μ Pa, at any instant of time that occurs in a specified frequency range. The level is calculated as ten times the logarithm to the base 10 of the ratio of the time-meansquare pressure of the sound to the square of the reference sound pressure of 20 μ Pa. <i>Note/ Typical aircraft noise certification usage refers to a specific onethird octave band, e.g. SPL(i,k) for the i-th band of the k-th spectrum in an aircraft noise time-history</i>

Symbol	Unit	Meaning
SPL _R	dB	<i>Reference sound pressure level.</i> The one-third octave band sound pressure levels adjusted to reference conditions
SPL _S	dB	<i>Slow weighted sound pressure level.</i> The value of one-third octave band sound pressure levels with time weighting S applied.
Δ ₁	TPNdB	<i>PNLTM adjustment.</i> Under Appendix 2 or Attachment F. In the simplified adjustment method, the adjustment to be added to the measured EPNL to account for noise level changes due to differences in atmospheric absorption and noise path length, between test and reference conditions at PNLTM.
	dB(A)	Under Appendix 4. The adjustments to be added to the measured LAE to account for noise level changes for spherical spreading and duration due to the difference between test and reference helicopter height.
	dB(A)	Under Appendix 6. For propeller-driven aeroplanes not exceeding 8 618 kg, the adjustment to be added to the measured LASmax to account for the noise level changes due to the difference between test and reference propeller helical tip Mach number..
Δ ₂	TPNdB	<i>Duration adjustment.</i> Under Appendix 2 or Attachment F. In the simplified adjustment method, the adjustment to be added to the measured EPNL to account for noise level changes due to the change in noise duration, caused by differences between test and reference aircraft speed and position relative to the microphone.
	dB(A)	Under Appendix 4. The adjustments to be added to the measured LAE to account for noise level changes due to the difference between reference and adjusted airspeed
	dB(A)	Under Appendix 6. For propeller-driven aeroplanes not exceeding 8 618 kg, the adjustment to be added to the measured LASmax to account for



Symbol	Unit	Meaning
		the noise level changes due to the difference between test and reference propeller helical tip Mach number.
Δ_3	TPNdB	<i>Source noise adjustment.</i> Under Appendix 2. In the simplified or integrated adjustment method, the adjustment to be added to the measured EPNL to account for noise level changes due to differences in source noise generating mechanisms, between test and reference conditions.
	dB(A)	Under Appendix 6. For propeller-driven aeroplanes not exceeding 8 618 kg, the adjustment to be added to the measured LAS _{max} to account for noise level changes due to the difference between test and reference engine power
Δ_4	dB (A)	<i>Atmospheric absorption adjustment.</i> Under Appendix 6. For propeller-driven aeroplanes not exceeding 8 618 kg, the adjustment to be added to the measured LAS _{max} for noise level changes due to the change in atmospheric absorption, caused by the difference between test and reference aeroplane heights.
$\Delta A(i)$	dB	<i>Atmospheric absorption adjustment.</i> For aircraft evaluated under Appendix 2, the total atmospheric absorption adjustment computed for one third octave band i for test-day atmospheric conditions.
$\Delta AP(i)$	dB	<i>Reference Atmospheric absorption adjustment.</i> For aircraft evaluated under Appendix 2, the total atmospheric absorption adjustment computed for one third octave band i for reference atmospheric conditions.
Δ_B	TPNdB	<i>Bandsharing adjustment.</i> The adjustment to be added to the maximum PNL _T to account for possible suppression of a tone due to one-third octave bandsharing of that tone. PNL _{TM} is equal to the maximum PNL _T plus Δ_B .
Δ_{BR}	TPNdB	<i>Reference bandsharing adjustment.</i> The adjustment to be added to the maximum PNL _R in the integrated method to account for possible

Symbol	Unit	Meaning
		suppression of a tone due to one-third octave bandsharing of that tone. $PNLTM_R$ is equal to the maximum $PNLT_R$ plus Δ_{BR} .
Δ_{peak}	TPNdB	<i>Peak adjustment.</i> The adjustment to be added to the measured EPNL for when the PNL _T for a secondary peak, identified in the calculation of EPNL from measured data and adjusted to reference conditions, is greater than the PNL _T for the adjusted PNL _{TM} spectrum.

1.5 Calculation of PNL and tone correction

Symbol	Unit	Meaning
C	dB	Tone correction factor. The factor to be added to the PNL of a given spectrum to account for the presence of spectral irregularities, such as tones.
f		Frequency. The nominal geometric mean frequency of a one-third octave band.
F	dB	Delta-dB. The difference between the original sound pressure level and the final broadband sound pressure level of a one-third octave band in a given spectrum.
$Log n(a)$	-	Noy discontinuity coordinate. The log n value of the intersection point of the straight lines representing the variation of SPL with log n.
M	-	Noy inverse slope. The reciprocals of the slopes of straight lines representing the variation of SPL with log n.
s	dB	Slope of sound pressure level. The change in level between adjacent one-third octave band sound pressure levels in a given spectrum.
Δs	dB	Change in slope of sound pressure level.
s'	dB	Adjusted slope of sound pressure level. The change in level between adjacent adjusted one-third octave band sound pressure levels in a given spectrum.
\bar{s}	dB	Average slope of sound pressure level.
$SPL(a)$	dB	Noy discontinuity level. The SPL value at the discontinuity coordinate of the straight lines representing the variation of SPL with log n.
$SPL(b)$ $SPL(c)$	dB	Noy intercept levels. The intercepts on the SPL-axis of the straight lines representing the variation of SPL with log n.

<i>SPL(d)</i>	dB	Noy discontinuity level. The SPL value at the discontinuity coordinate where log n equals -1.
<i>SPL(e)</i>	dB	Noy discontinuity level. The SPL value at the discontinuity coordinate where log n equals log 0.3.
<i>SPL'</i>	dB	Adjusted sound pressure level. The first approximation to broadband sound pressure level in a one-third octave band of a given spectrum.
<i>SPL''</i>	dB	Final broadband sound pressure level. The second and final approximation to broadband sound pressure level in a one-third octave band of a given spectrum.

1.6 Flight path geometry

Symbol	Unit	Meaning
H	m	Height. The aircraft height at the point where the flight path intercepts the vertical geometrical plane perpendicular to the reference ground track at the centre microphone.
H _R	m	<i>Reference height.</i> The reference aircraft height at the point where the reference flight path intercepts the vertical geometrical plane perpendicular to the reference ground track at the centre microphone.
X	m	<i>Aircraft position along the ground track.</i> The position coordinate of the aircraft along the x-axis at a specific point in time.
Y	m	<i>Lateral aircraft position relative to the reference ground track.</i> The position coordinate of the aircraft along the y-axis at a specific point in time.
Z	m	<i>Vertical aircraft position relative to the reference ground track.</i> The position coordinate of the aircraft along the z-axis at a specific point in time.
ϑ	degrees	Sound emission angle. The angle between the flight path and the direct sound propagation path to the microphone. The angle is identical for both the measured and reference flight paths.
ψ	degrees	Elevation angle. The angle between the sound propagation path and a horizontal plane passing through the microphone, where the sound propagation path is defined as a line between a sound emission point on the measured flight path and the microphone diaphragm.
ψ_R	degrees	Reference elevation angle. The angle between the reference sound propagation path and a horizontal plane passing through the reference microphone location, where the reference sound propagation path is defined as a line between a sound emission point on the reference flight path and the reference microphone diaphragm.

1.7 Miscellaneous

Symbol	Unit	Meaning
antilog	-	Antilogarithm to the base 10.
D	m	Diameter. Propeller or rotor diameter.
D ₁₅	m	Take-off distance. The take-off distance required for an aeroplane to reach 15 m height above ground level.
<i>e</i>	-	Euler's number. The mathematical constant that is the base number of the natural logarithm, approximately 2.71828.
<i>log</i>	-	Logarithm to the base 10.
N	rpm	Propeller speed.
N ₁	rpm	Compressor speed. The turbine engine low pressure compressor first stage fan speed.
RH	%	Relative humidity. The ambient atmospheric relative humidity.
T	°C	Temperature. The ambient atmospheric temperature.
u	m/s	Wind speed along-track component. The component of the wind speed vector along the reference ground track.
v	m/s	Wind speed cross-track component. The component of the wind speed vector horizontally perpendicular to the reference ground track.
α	dB/100 m	Test atmospheric absorption coefficient. The sound attenuation rate, due to atmospheric absorption, that occurs in a specified one-third octave band for the measured ambient temperature and relative humidity
α_R	dB/100 m	Reference atmospheric absorption coefficient. The sound attenuation rate, due to atmospheric absorption, that occurs in a specified one-third octave band for a reference ambient temperature and relative humidity.

μ	-	Engine noise performance parameter. For jet aeroplanes, typically the normalized low pressure fan speed, normalized engine thrust, or engine pressure ratio used in the calculation of the source noise adjustment.
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PART II. AIRCRAFT NOISE CERTIFICATION

CHAPTER 1. ADMINISTRATION

- 1.1 The provisions of 1.2 to 1.6 should apply to all aircraft included in the classifications defined for noise certification purposes in Chapters 2, 3, 4, 5, 6, 8, 10, 11, 12, 13 and 14 of this part where such aircraft are engaged in international air navigation.
- 1.2 Noise certification should be granted or validated by the State of Registry of an aircraft on the basis of satisfactory evidence that the aircraft complies with requirements that are at least equal to the applicable Standards specified in this Part.
- 1.3 If noise recertification is requested, it should be granted or validated by the State of Registry of an aircraft on the basis of satisfactory evidence that the aircraft complies with requirements that are at least equal to the applicable Standards specified in this Part. The date used by a certifying authority to determine the recertification basis should be the date of acceptance of the first application for recertification.
- 1.4 The documents attesting noise certification should be approved by the State of Registry and should be required by that State to be carried on the aircraft.


Note - See part 6, Part I, 6.13, concerning the translation into English of documents attesting noise certification.

- 1.5 The documents attesting noise certification for an aircraft should provide at least the following information:
- Item 1 Name of State.
 - Item 2 Title of the noise document. Item 3. Number of the document.
 - Item 4 Nationality or common mark and registration marks. Item 5. Manufacturer and manufacturer's designation of aircraft. Item 6. Aircraft serial number.
 - Item 7 Engine manufacturer, type and model.
 - Item 8 Propeller type and model for propeller-driven aeroplanes. Item 9. Maximum take-off mass in kilograms.
 - Item 10 Maximum landing mass, in kilograms, for certificates issued under Chapters 2,

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3, 4, 5, 12 and 14 of this part.

- Item 11. The chapter and section of this part according to which the aircraft was certificated.
 - Item 12. Additional modifications incorporated for the purpose of compliance with the applicable noise certification Standards.
 - Item 13. The lateral/full-power noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 12 and 14 of this part.
 - Item 14. The approach noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 8, 12, 13 and 14 of this part.
 - Item 15. The flyover noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 12 and 14 of this part.
 - Item 16. The overflight noise level in the corresponding unit for documents issued under Chapters 6, 8, 11 and 13 of this part.
 - Item 17. The take-off noise level in the corresponding unit for documents issued under Chapters 8, 10 and 13 of this part.
 - Item 18. Statement of compliance, including a reference to part 16, Volume I.
 - Item 19. Date of issuance of the noise certification document.
 - Item 20. Signature of the officer issuing it.
- 1.6 Item headings on the noise certification documents should be uniformly numbered in Arabic numerals, as indicated in 1.5, so that on any noise certification document the number will, under any arrangement, refer to the same item heading, except where the information in Items 1 through 6 and Items 18 through 20 is given in the certificate of airworthiness, in which case the numbering system of the certificate of airworthiness according to Part 8 should prevail.
- 1.7 An administrative system for implementation of noise certification documentation should be developed by the State of Registry.
- Note- See Attachment G for guidance on the format and structure of noise certification documentation.*
- 1.8 The state of Kuwait should recognize as valid a noise certification granted by another Contracting State provided that the requirements under which such certification was granted are at least equal to the applicable Standards specified in this Part.
- 1.9 The state of Kuwait should suspend or revoke the noise certification of an aircraft on its

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register if the aircraft ceases to comply with the applicable noise Standards. The State of Registry should not remove the suspension of a noise certification or grant a new noise certification unless the aircraft is found, on reassessment, to comply with the applicable noise Standards.

- 1.10 The amendment of this volume of the Part to be used by a Contracting State should be that which is applicable on the date of submission to that Contracting State for:
- a) a Type Certificate in the case of a new type; or
 - b) approval of a change in type design in the case of a derived version; or
 - c) in either case, under an equivalent application procedure prescribed by the certifying authority of that Contracting State.

Note.- As each new edition and amendment of this Part becomes applicable (according to Table A of the Foreword) it supersedes all previous editions and amendments.

- 1.11 The date to be used by the state of Kuwait in determining the applicability of the Standards in this part should be the date the application for a Type Certificate was submitted to the State of Design, or the date of submission under an equivalent application procedure prescribed by the certifying authority of the State of Design.
- 1.12 For derived versions where the provisions governing the applicability of the Standards of this part refer to “the application for the certification of the change in type design”, the date to be used by the state of Kuwait in determining the applicability of the Standards in this part should be the date the application for the change in type design was submitted to the Contracting State that first certified the change in type design, or the date of submission under an equivalent application procedure prescribed by the certifying authority of the Contracting State that first certified the change in type design.
- 1.13 An application should be effective for the period specified in the designation of the airworthiness regulations appropriate to the aircraft type, except in special cases where the certifying authority accepts an extension of this period. When this period of affectivity is exceeded, the date to be used in determining the applicability of the Standards in this part should be the date of issue of the Type Certificate or approval of the change in type design, or the date of issue of approval under an equivalent procedure prescribed by the State of Design, less the period of affectivity.

Note 1- Unless otherwise specified in this volume of the Part, the edition of the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft, to be used as guidance on the use of acceptable means of compliance and equivalent procedures by a Contracting State is in general the edition which is in effect on the date the application for a Type Certificate or the change in type design is submitted to that Contracting State.

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Note 2 - *The means of compliance and the use of equivalent procedures are subject to the acceptance of the certifying authority of the Contracting State.*

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CHAPTER 2. SUBSONIC JET AEROPLANES - Application for Type Certificate submitted before 6 October 1977

2.1 Applicability

Note- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

- 2.1.1 The Standards of this chapter should be applicable to all subsonic jet aeroplanes for which the application for a Type Certificate was submitted before 6 October 1977, except those aeroplanes:
- a) requiring a runway length¹ of 610 m or less at maximum certificated mass for airworthiness; or
 - b) powered by engines with a bypass ratio of 2 or more and for which a certificate of airworthiness for the individual aeroplane was first issued before 1 March 1972; or
 - c) powered by engines with a bypass ratio of less than 2 and for which the application for a Type Certificate was submitted before 1 January 1969, and for which a certificate of airworthiness for the individual aeroplane was first issued before 1 January 1976.
- 2.1.2 The maximum noise levels of 2.4.1 should apply except for derived versions for which the application for certification of the change in type design was submitted on or after 26 November 1981, in which case the maximum noise levels of 2.4.2 should apply.
- 2.1.3 Notwithstanding 2.1.1 and 2.1.2, it may be recognized by a Contracting State that the following situations for jet aeroplanes, and propeller-driven aeroplanes over 8618 kg maximum certificated take-off mass on its registry do not require demonstration of compliance with the provisions of the Standards of Part 16, Volume I:
- a) gear down flight with one or more retractable landing gear down during the entire flight;
 - b) spare engine and nacelle carriage external to the skin of the aeroplane (and return of the pylon or other external mount); and
 - c) time-limited engine and/or nacelle changes, where the change in type design specifies that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of Part 16, Volume I, is shown for that change in type design. This applies only to changes resulting from a required maintenance action.

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2.2 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 1

1. With no stopway or clearway.

2.3 Noise measurement points

An aeroplane, when tested in accordance with the flight test procedures of 2.6, should not exceed the noise levels specified in 2.4 at the following points:

- a) *lateral noise measurement point*: the point on a line parallel to and 650 m from the runway center line, or extended runway center line, where the noise level is a maximum during take-off;
- b) *flyover noise measurement point*: the point on the extended center line of the runway and at a distance of 6.5 km from the start of roll; and
- c) *approach noise measurement point*: the point on the ground, on the extended center line of the runway, 120 m (394 ft) vertically below the 3° descent path originating from a point 300 m beyond the threshold. On level ground this corresponds to a position 2000 m from the threshold.

2.4 Maximum noise levels


2.4.1 The maximum noise levels of those aeroplanes covered by 2.1.1, when determined in accordance with the noise evaluation method of Appendix 1, should not exceed the following:

- a) *at lateral and approach noise measurement points*: 108 EPNdB for aeroplanes with maximum certificated take-off mass of 272000 kg or over, decreasing linearly with the logarithm of the mass at the rate of 2 EPNdB per halving of the mass down to 102 EPNdB at 34000 kg, after which the limit remains constant;
- b) *at flyover noise measurement point*: 108 EPNdB for aeroplanes with maximum certificated take-off mass of 272000 kg or over, decreasing linearly with the logarithm of the mass at the rate of 5 EPNdB per halving of the mass down to 93 EPNdB at 34000 kg, after which the limit remains constant.

Note- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

2.4.2 The maximum noise levels of those aeroplanes covered by 2.1.2, when determined in accordance with the noise evaluation method of Appendix 1, should not exceed the

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following:

2.4.2.1 *At lateral noise measurement point*

106 EPNdB for aeroplanes with maximum certificated take-off mass of 400000 kg or over, decreasing linearly with the logarithm of the mass down to 97 EPNdB at 35000 kg, after which the limit remains constant.

2.4.2.2 *At flyover noise measurement point*

a) *Aeroplanes with two engines or less*

104 EPNdB for aeroplanes with maximum certificated take-off mass of 325000 kg or over, decreasing linearly with the logarithm of the mass at the rate of 4 EPNdB per halving of mass down to 93 EPNdB, after which the limit remains constant.

b) *Aeroplanes with three engines*

As a) but with 107 EPNdB for aeroplanes with maximum certificated take-off mass of 325000 kg or over

or

as defined by 2.4.1 b) whichever is the lower.

c) *Aeroplanes with four engines or more*

As a) but with 108 EPNdB for aeroplanes with maximum certificated take-off mass of 325000 kg or over

or

as defined by 2.4.1 b) whichever is the lower.

2.4.2.3 *At approach noise measurement point*

108 EPNdB for aeroplanes with maximum certificated take-off mass of 280000 kg or over, decreasing linearly with the logarithm of the mass down to 101 EPNdB at 35000 kg, after which the limit remains constant.

Note.- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

2.5 Trade-offs

If the maximum noise levels are exceeded at one or two measurement points:

- a) the sum of excesses should not be greater than 4 EPNdB, except that in respect of four-engined aeroplanes powered by engines with a bypass ratio of 2 or more and

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for which the application for a certificate of airworthiness for the prototype was accepted, or another equivalent prescribed procedure was carried out by the certifying authority, before 1 December 1969, the sum of any excesses should not be greater than 5 EPNdB;

- b) any excess at any single point should not be greater than 3 EPNdB; and
- c) any excesses should be offset by corresponding reductions at the other point or points.

2.6 Test procedures

2.6.1 Take-off test procedure

2.6.1.1 Average take-off thrust (Take-off thrust representative of the mean characteristics of the production engine) should be used from the start of take-off to the point at which a height of at least 210 m (690 ft) above the runway is reached, and the thrust thereafter should not be reduced below that thrust which will maintain a climb gradient of at least 4 per cent.

A speed of at least $V_2 + 19$ km/h ($V_2 + 10$ kt) should be attained as soon as practicable after lift-off and be maintained throughout the take-off noise certification test.

2.6.1.2 A constant take-off configuration selected by the applicant should be maintained throughout the take-off noise certification demonstration test except that the landing gear may be retracted.


2.6.2 Approach test procedure

2.6.2.1 The aeroplane should be stabilized and following a $3^\circ \pm 0.5^\circ$ glide path.

2.6.2.2 The approach should be made at a stabilized airspeed of not less than $1.3 V_S + 19$ km/h ($1.3 V_S + 10$ kt) with thrust stabilized during approach and over the measuring point and continued to a normal touchdown.

2.6.2.3 The configuration of the aeroplane should be with maximum allowable landing flap setting.

Note.-Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.

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CHAPTER 3.

3.1 Applicability

Note 1-See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

Note 2-See Attachment E for guidance on interpretation of these applicability provisions.

3.1.1 The Standards of this chapter should, with the exception of those propeller-driven aeroplanes specifically designed and used for agricultural or firefighting purposes, be applicable to:

- a) all subsonic jet aeroplanes, including their derived versions, other than aeroplanes which require a runway¹ length of 610 m or less at maximum certificated mass for airworthiness, for which the application for a Type Certificate was submitted on or after 6 October 1977 and before 1 January 2006; and
- b) all propeller-driven aeroplanes, including their derived versions, of over 8618 kg maximum certificated take-off mass, for which the application for a Type Certificate was submitted on or after 1 January 1985 and before 1 January 2006.

3.1.2 Notwithstanding 3.1.1, it may be recognized by the state of Kuwait that the following situations for jet aeroplanes, and propeller-driven aeroplanes over 8 618 kg maximum certificated take-off mass on its registry do not require demonstration of compliance with the provisions of the Standards of part 16, Volume I:

- a) gear down flight with one or more retractable landing gear down during the entire flight;
- b) spare engine and nacelle carriage external to the skin of the aeroplane (and return of the pylon or other external mount); and
- c) time-limited engine and/or nacelle changes, where the change in type design specifies that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of Part 16, Volume I, is shown for that change in type design. This applies only to changes resulting from a required maintenance action.

3.2 Noise measurements

3.2.1 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2.

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3.3 Noise measurement points

3.3.1 Reference noise measurement points

An aeroplane, when tested in accordance with these Standards, should not exceed the noise levels specified in 3.4 at the following points:

- a) *lateral full-power reference noise measurement point*
- 1) for jet-powered aeroplanes: the point on a line parallel to and 450 m from the runway center line, where the noise level is a maximum during take-off;
 - 2) for propeller-driven aeroplanes: the point on the extended center line of the runway 650 m vertically below the climb-out flight path at full take-off power, as defined in 3.6.2. Until 19 March 2002, the requirement for lateral noise in 3.3.1 a) 1) should alternatively be permitted;


Note- For aeroplanes specified in 3.1.1 b) for which the application for a Type Certificate was submitted before 19 March 2002, the lateral noise requirement specified in 3.3.1 a) 1) is permitted as an alternative.

- b) *flyover reference noise measurement point*: the point on the extended center line of the runway *and at a distance of 6.5 km from the start of roll*;
- c) *approach reference noise measurement point*: *the point on the ground, on the extended center line of the runway, 2000 m from the threshold. On level ground this corresponds to a position 120 m (394 ft) vertically below the 3° descent path originating from a point 300 m beyond the threshold.*

3.3.2 Test noise measurement points

3.3.2.1 If the test noise measurement points are not located at the reference noise measurement points, any corrections for the difference in position should be made in the same manner as the corrections for the differences between test and reference flight paths.

3.3.2.2 Sufficient lateral test noise measurement points should be used to demonstrate to the certificating authority that the maximum noise level on the appropriate lateral line has been clearly determined. For jet-powered aeroplanes simultaneous measurements should be made at one test noise measurement point at a symmetrical position on the other side of the runway. In the case of propeller-driven aeroplanes, because of their inherent asymmetry in lateral noise, simultaneous measurements should be made at each and every test noise measurement point at a symmetrical position (within ± 10 m parallel with the axis of the runway) on the opposite side of the runway.

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3.4 Maximum noise levels

3.4.1 The maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed the following:

3.4.1.1 *At the lateral full-power reference noise measurement point* 103 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 400000 kg and over and decreasing linearly with the logarithm of the mass down to 94 EPNdB at 35000 kg, after which the limit remains constant.

3.4.1.2 *At flyover reference noise measurement point*

a) *Aeroplanes with two engines or less*

101 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 385 000 kg and over and decreasing linearly with the logarithm of the aeroplane mass at the rate of 4 EPNdB per halving of mass down to 89 EPNdB, after which the limit is constant.

b) *Aeroplanes with three engines*

As a) but with 104 EPNdB for aeroplanes with maximum certificated take-off mass of 385000 kg and over.

c) *Aeroplanes with four engines or more*

As a) but with 106 EPNdB for aeroplanes with maximum certificated take-off mass of 385000 kg and over.

3.4.1.3 *At approach reference noise measurement point*

105 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 280000 kg or over, and decreasing linearly with the logarithm of the mass down to 98 EPNdB at 35000 kg, after which the limit remains constant.

Note- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

3.5 Trade-offs


If the maximum noise levels are exceeded at one or two measurement points:

a) the sum of excesses should not be greater than 3 EPNdB;

b) any excess at any single point should not be greater than 2 EPNdB; and

c) any excesses should be offset by corresponding reductions at the other point or points.

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3.6 Noise certification reference procedures

3.6.1 General conditions

3.6.1.1 The reference procedures should comply with the appropriate airworthiness requirements.

3.6.1.2 The calculations of reference procedures and flight paths should be approved by the certifying authority.

3.6.1.3 Except in conditions specified in 3.6.1.4, the take-off and approach reference procedures should be those defined in 3.6.2 and 3.6.3, respectively.

3.6.1.4 When it is shown by the applicant that the design characteristics of the aeroplane would prevent flight being conducted in accordance with 3.6.2 and 3.6.3, the reference procedures should:

- a) depart from the reference procedures defined in 3.6.2 and 3.6.3 only to the extent demanded by those design characteristics which make compliance with the procedures impossible; and
- b) be approved by the certifying authority.

3.6.1.5 The reference procedures should be calculated under the following reference atmospheric conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 25°C, i.e. ISA + 10°C;
- c) relative humidity of 70 per cent;
- d) zero wind; and
- e) for the purpose of defining the reference take-off profiles for both take-off and lateral noise measurements, the runway gradient is zero.

Note—The reference atmosphere in terms of temperature and relative humidity is homogeneous when used for the calculation of atmospheric absorption coefficients.

3.6.2 Take-off reference procedure

Take-off reference flight path should be calculated as follows:

- a) average engine take-off thrust or power should be used from the start of take-off to the point where at least the following height above runway level is reached:
 - 1) aeroplanes with two engines or less — 300 m (984 ft);

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- 2) aeroplanes with three engines — 260 m (853 ft);
 - 3) aeroplanes with four engines or more — 210 m (689 ft);
- b) upon reaching the height specified in a) above, the thrust or power should not be reduced below that required to maintain:
- 1) a climb gradient of 4 per cent; or
 - 2) in the case of multi-engined aeroplanes, level flight with one engine inoperative; whichever thrust or power is greater;
- c) for the purpose of determining the lateral full-power noise level, the reference flight path should be calculated on the basis of using full take-off power throughout without a thrust or power reduction;
- d) the speed should be:
- 1) for those aeroplanes for which the applicable airworthiness requirements define V_2 , the all-engines operating take-off climb speed selected by the applicant for use in normal operation, which should be at least $V_2 + 19$ km/h ($V_2 + 10$ kt) but not greater than $V_2 + 37$ km/h ($V_2 + 20$ kt) and which should be attained as soon as practicable after lift-off and be maintained throughout the take-off noise certification test. The increment applied to V_2 should be the same for all reference masses of an aeroplane model unless a difference in increment is substantiated based on performance characteristics of the aeroplane.

Note- V_2 is defined in accordance with the applicable airworthiness requirements.

- 2) for those aeroplanes for which the applicable airworthiness requirements do not define V_2 , the take-off speed at 15 m (50 ft) plus an increment of at least 19 km/h (10 kt) but not greater than 37 km/h (20 kt), or the minimum climb speed, whichever speed is greater. This speed should be attained as soon as practicable after lift-off and be maintained throughout the take-off noise certification test.

Note.- Take-off speed at 15 m (50 ft) and minimum climb speed are defined in accordance with the applicable airworthiness requirements.

- e) a constant take-off configuration selected by the applicant should be maintained throughout the take-off reference procedure except that the landing gear may be retracted. Configuration should be interpreted as meaning the conditions of the systems and center of gravity position and should include the position of lift augmentation devices used, whether the APU is operating, and whether air

bleeds and power off-takes are operating;

- f) the mass of the aeroplane at the brake release should be the maximum take-off mass at which the noise certification is requested; and
- g) the average engine should be defined by the average of all the certification compliant engines used during the aeroplane flight tests up to and during certification when operated to the limitations and procedures given in the flight manual. This will establish a technical standard including the relationship of thrust/power to control parameters (e.g. N_1 or EPR). Noise measurements made during certification tests should be corrected to this standard.
- h) Take-off thrust/power used should be the maximum available for normal operations as scheduled in the performance section of the aeroplane flight manual for the reference atmospheric conditions given in 3.6.1.5.

3.6.3 Approach reference procedure

The approach reference flight path should be calculated as follows:

- a) the aeroplane should be stabilized and following a 3° glide path;
- b) a steady approach speed of $V_{REF} + 19$ km/h ($V_{REF} + 10$ kt), with thrust or power stabilized, should be maintained over the measurement point;

Note- In airworthiness terms V_{REF} is defined as the “reference landing speed”. Under this definition reference landing speed means “the speed of the aeroplane, in a specified landing configuration, at the point where it descends through the landing screen height in the determination of the landing distance for manual landings”.


- c) the constant approach configuration as used in the airworthiness certification tests, but with the landing gear down, should be maintained throughout the approach reference procedure;
- d) the mass of the aeroplane at the touchdown should be the maximum landing mass permitted in the approach configuration defined in 3.6.3 c) at which noise certification is requested; and
- e) the most critical (that which produces the highest noise level) configuration with normal deployment of aerodynamic control surfaces including lift and drag producing devices, at the mass at which certification is requested should be used. This configuration includes all those items listed in 5.2.5 of Appendix 2 that will contribute to the noisiest continuous state at the maximum landing mass in normal operation.

3.7 Test procedures

- 3.7.1 The test procedures should be acceptable to the airworthiness and noise certificating authority of the State issuing the certificate.
- 3.7.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated as effective perceived noise level, EPNL, in units of EPNdB, as described in Appendix 2.
- 3.7.3 Acoustic data should be adjusted by the methods outlined in Appendix 2 to the reference conditions specified in this chapter. Adjustments for speed and thrust should be made as described in Section 8 of Appendix 2.
- 3.7.4 If the mass during the test is different from the mass at which the noise certification is requested, the necessary EPNL adjustment should not exceed 2 EPNdB for take-offs and 1 EPNdB for approaches. Data approved by the certificating authority should be used to determine the variation of EPNL with mass for both take-off and approach test conditions. Similarly the necessary EPNL adjustment for variations in approach flight path from the reference flight path should not exceed 2 EPNdB.
- 3.7.5 For the approach conditions the test procedures should be accepted if the aeroplane follows a steady glide path angle of $3^{\circ} \pm 0.5^{\circ}$.
- 3.7.6 If equivalent test procedures different from the reference procedures are used, the test procedures and all methods for adjusting the results to the reference procedures should be approved by the certificating authority. The amounts of the adjustments should not exceed 16 EPNdB on take-off and 8 EPNdB on approach, and if the adjustments are more than 8 EPNdB and 4 EPNdB, respectively, the resulting numbers should be more than 2 EPNdB below the noise limits specified in

Note- Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.

- 3.7.7 For take-off, lateral, and approach conditions, the variation in instantaneous indicated airspeed of the aeroplane shall be maintained within ± 3 per cent of the average airspeed between the 10 dB-down points. This should be determined by reference to the pilot's airspeed indicator. However, when the instantaneous indicated airspeed varies from the average airspeed over the 10 dB-down points by more than ± 5.5 km/h (± 3 kt), and this is judged by the certificating authority representative on the flight deck to be due to atmospheric turbulence, then the flight so affected should be rejected for noise certification purposes.

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CHAPTER 4.

4.1 Applicability

Note- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

The Standards of this chapter should, with the exception of those aeroplanes which require a runway¹ length of 610 m or less at maximum certificated mass for airworthiness or propeller-driven aeroplanes specifically designed and used for agricultural or firefighting purposes, be applicable to:

- a) all subsonic jet aeroplanes and propeller-driven aeroplanes, including their derived versions, with a maximum certificated take-off mass of 55000 kg and over for which the application for a Type Certificate was submitted on or after 1 January 2006 and before 31 December 2017;
- b) all subsonic jet aeroplanes, including their derived versions, with a maximum certificated take-off mass of less than 55000 kg for which the application for a Type Certificate was submitted on or after 1 January 2006 and before 31 December 2020;
- c) all propeller-driven aeroplanes, including their derived versions, with a maximum certificated take-off mass of over 8618 kg and less than 55000 kg, for which the application for a Type Certificate was submitted on or after 1 January 2006 and before 31 December 2020; and
- d) all subsonic jet aeroplanes and all propeller-driven aeroplanes certificated originally as satisfying Part 16, Volume 1, Chapter 3 or Chapter 5, for which recertification to Chapter 4 is requested.

Note - Guidance material on applications for recertification is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.

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1. With no stopway or clearway.

4.1.2 Notwithstanding 4.1.1, it may be recognized by a Contracting State that the following situations for jet aeroplanes and propeller-driven aeroplanes over 8 618 kg maximum certificated take-off mass on its registry do not require demonstration of compliance with the provisions of the Standards of part 16, Volume I:

- a) gear down flight with one or more retractable landing gear down during the entire flight;
- b) spare engine and nacelle carriage external to the skin of the aeroplane (and return of the pylon or other external mount); and

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- c) time-limited engine and/or nacelle changes, where the change in type design specifies that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of part 16, Volume I, is shown for that change in type design. This applies only to changes resulting from a required maintenance action.

4.2 Noise measurements

4.2.1 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2.

4.3 Reference noise measurement points

- 4.3.1 An aeroplane, when tested in accordance with these Standards, should not exceed the maximum noise level specified in 4.4 of the noise measured at the points specified in Chapter 3, 3.3.1 a), b) and c).

4.3.2 Test noise measurement points

The provisions of Chapter 3, 3.3.2, relating to test noise measurement points should apply.

4.4 Maximum noise levels

- 4.4.1 The maximum permitted noise levels are defined in Chapter 3, 3.4.1.1, 3.4.1.2 and 3.4.1.3, and should not be exceeded at any of the measurement points.

- 4.4.1.1 The sum of the differences at all three measurement points between the maximum noise levels and the maximum permitted noise levels specified in Chapter 3, 3.4.1.1, 3.4.1.2 and 3.4.1.3, should not be less than 10 EPNdB.

- 4.4.1.2 The sum of the differences at any two measurement points between the maximum noise levels and the corresponding maximum permitted noise levels specified in Chapter 3, 3.4.1.1, 3.4.1.2 and 3.4.1.3, should not be less than EPNdB.

Note-See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

4.5 Noise certification reference procedures


The noise certification reference procedures should be as specified in Chapter 3, 3.6.

4.6 Test procedures

The test procedures should be as specified in Chapter 3, 3.7.

4.7 Recertification

For aeroplanes specified in 4.1.1 c), recertification should be granted on the basis that the evidence used to determine compliance with Chapter 4 is as satisfactory as the evidence associated with aeroplanes specified in 4.1.1 a) and b).

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CHAPTER 5. PROPELLER-DRIVEN AEROPLANES OVER 8618 kg - Application for Type Certificate submitted before 1 January 1985

5.1 Applicability

Note 1.- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

Note 2.- See Attachment E for guidance on interpretation of these applicability provisions.

5.1.1 The Standards defined hereunder are not applicable to:

- a) aeroplanes requiring a runway¹ length of 610 m or less at maximum certificated mass for airworthiness;
- b) aeroplanes specifically designed and used for firefighting purposes; and
- c) aeroplanes specifically designed and used for agricultural purposes.

5.1.2 The Standards of this chapter should be applicable to all propeller-driven aeroplanes, including their derived versions, of over 8618 kg maximum certificated take-off mass for which either the application for a Type Certificate was submitted on or after 6 October 1977 and before 1 January 1985.

5.1.3 The Standards of Chapter 2, with the exception of Sections 2.1 and 2.4.2, should be applicable to propeller-driven aeroplanes of over 8618 kg for which the application for a Type Certificate was submitted before 6 October 1977 and which are either:

- a) derived versions for which the application for certification of the change in type design was submitted on or after 6 October 1977; or
- b) individual aeroplanes for which a certificate of airworthiness was first issued on or after 26 November 1981.

Note.-The Standards in Chapters 2 and 3 although developed previously for subsonic jet aeroplanes are considered suitable for application to other aeroplane types regardless of the type of power installed.

5.1.4 Notwithstanding 5.1.2 and 5.1.3, it may be recognized by a Contracting State that the following situations for jet aeroplanes, and propeller-driven aeroplanes over 8618 kg maximum certificated take-off mass on its registry do not require demonstration of compliance with the provisions of the Standards of Part 16, Volume I:

- a) gear down flight with one or more retractable landing gear down during the entire flight;
- b) spare engine and nacelle carriage external to the skin of the aeroplane (and return of the pylon or other external mount); and
- c) time-limited engine and/or nacelle changes, where the change in type design specifies that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of Part 16, Volume I, is shown for that

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change in type design. This applies only to changes resulting from a required maintenance action.

1. With no stopway or clearway.

5.2 Noise measurements

5.2.1 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2.

5.3 Noise measurement points

5.3.1 Reference noise measurement points

An aeroplane, when tested in accordance with these Standards, should not exceed the noise levels specified in 5.4 at the following points:


- a) lateral reference noise measurement point: the point on a line parallel to and 450 m from the runway center line, or extended runway center line, where the noise level is a maximum during take-off;
- b) flyover reference noise measurement point: the point on the extended center line of the runway and at a distance of 6.5 km from the start of roll; and
- c) approach reference noise measurement point: the point on the ground, on the extended center line of the runway, 2 000 m from the threshold. On level ground this corresponds to a position 120 m (394 ft) vertically below the 3° descent path originating from a point 300 m beyond the threshold.

5.3.2 Test noise measurement points

5.3.2.1 If the test noise measurement points are not located at the reference noise measurement points, any corrections for the difference in position should be made in the same manner as the corrections for the differences between test and reference flight paths.

5.3.2.2 Sufficient lateral test noise measurement points should be used to demonstrate to the certificating authority that the maximum noise level on the appropriate lateral line has been clearly determined. Simultaneous measurements should be made at one test noise measurement point at a symmetrical position on the other side of the runway.

5.3.2.3 The applicant should demonstrate to the certificating authority that during flight test, lateral and flyover noise levels were not separately optimized at the expense of each other.

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5.4 Maximum noise levels

The maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed the following:

- a) *at lateral reference noise measurement point:* 96 EPNdB constant limit for aeroplanes with maximum take-off mass, at which the noise certification is requested, up to 34000 kg and increasing linearly with the logarithm of aeroplane mass at the rate of 2 EPNdB per doubling of mass from that point until the limit of 103 EPNdB is reached, after which the limit is constant;

- b) *at flyover reference noise measurement point:* 89 EPNdB constant limit for aeroplanes with maximum take-off mass, at which the noise certification is requested, up to 34000 kg and increasing linearly with the logarithm of aeroplane mass at the rate of 5 EPNdB per doubling of mass from that point until the limit of 106 EPNdB is reached, after which the limit is constant; and

- c) *at approach reference noise measurement point:* 98 EPNdB constant limit for aeroplanes with maximum take-off mass, at which the noise certification is requested, up to 34000 kg and increasing linearly with the logarithm of aeroplane mass at the rate of 2 EPNdB per doubling of mass from that point until the limit of 105 EPNdB is reached, after which the limit is constant.

Note.- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

5.5 Trade-offs

If the maximum noise levels are exceeded at one or two measurement points:

- a) the sum of excesses should not be greater than 3 EPNdB;
- b) any excess at any single point should not be greater than 2 EPNdB; and
- c) any excesses should be offset by corresponding reductions at the other point or points.


5.6 Noise certification reference procedures

5.6.1 General conditions

5.6.1.1 The reference procedures should comply with the appropriate airworthiness requirements.

5.6.1.2 The calculations of reference procedures and flight paths should be approved by the certifying authority.

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5.6.1.3 Except in conditions specified in 5.6.1.4, the take-off and approach reference procedures should be those defined in 5.6.2 and 5.6.3, respectively.

5.6.1.4 When it is shown by the applicant that the design characteristics of the aeroplane would prevent flight being conducted in accordance with 5.6.2 and 5.6.3, the reference procedures should:

- a) depart from the reference procedures defined in 5.6.2 and 5.6.3 only to the extent demanded by those design characteristics which make compliance with the procedures impossible; and
- b) be approved by the certificating authority.

5.6.1.5 The reference procedures should be calculated under the following reference atmospheric conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 25°C, i.e. ISA + 10°C except that at the discretion of the certificating authority, an alternative reference ambient air temperature of 15°C, i.e. ISA may be used;
- c) relative humidity of 70 per cent; and
- d) zero wind.

5.6.2 Take-off reference procedure The take-off flight path should be calculated as follows:

- a) average take-off power should be used from the start of take-off to the point where at least the height above runway level shown below is reached. The take-off power used should be the maximum available for normal operations as scheduled in the performance section of the aeroplane flight manual for the reference atmospheric conditions given in 5.6.1.5;
 - 1) aeroplanes with two engines or less - 300 m (984 ft);
 - 2) aeroplanes with three engines - 260 m (853 ft);
 - 3) aeroplanes with four engines or more - 210 m (689 ft);
- b) upon reaching the height specified in a) above, the power should not be reduced below that required to maintain:
 - 1) a climb gradient of 4 per cent; or

- 2) in the case of multi-engined aeroplanes, level flight with one engine inoperative; whichever power is the greater;
 - c) the speed should be the all- engines operating take-off climb speed selected by the applicant for use in normal operation, which should be at least $V_2 + 19$ km/h ($V_2 + 10$ kt) and which should be attained as soon as practicable after lift-off and be maintained throughout the take-off noise certification test;
 - d) a constant take-off configuration selected by the applicant should be maintained throughout the take-off reference procedure except that the landing gear may be retracted; and
 - e) the mass of the aeroplane at the brake release should be the maximum take-off mass at which the noise certification is requested.
- 5.6.3 Approach reference procedure the approach reference flight path should be calculated as follows:
- a) the aeroplane should be stabilized and following a 3° glide path;
 - b) the approach should be made at a stabilized airspeed of not less than $1.3 V_S + 19$ km/h ($1.3 V_S + 10$ kt) with power stabilized during approach and over the measuring point and continued to a normal touchdown;
 - c) the constant approach configuration used in the airworthiness certification test, but with the landing gear down, should be maintained throughout the approach reference procedure;
 - d) the mass of the aeroplane at the touchdown should be the maximum landing mass permitted in the approach configuration defined in 5.6.3 c) at which noise certification is requested; and
 - e) the most critical (that which produces the highest noise levels) configuration at the mass at which certification is requested should be used.

5.7 Test procedures

- 5.7.1 The test procedures should be acceptable to the airworthiness and noise certificating authority of the State issuing the certificate.
- 5.7.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated as effective perceived noise level, EPNL, in units of EPNdB, as described in Appendix 2.

- 5.7.3 Acoustic data should be adjusted by the methods outlined in Appendix 2 to the reference conditions specified in this chapter. Adjustments for speed and thrust should be made as described in Section 8 of Appendix 2.
- 5.7.4 If the mass during the test is different from the mass at which the noise certification is requested, the necessary EPNL adjustment should not exceed 2 EPNdB for take-offs and 1 EPNdB for approaches. Data approved by the certifying authority should be used to determine the variation of EPNL with mass for both take-off and approach test conditions. Similarly, the necessary EPNL adjustment for variations in approach flight path from the reference flight path should not exceed 2 EPNdB.
- 5.7.5 For the approach conditions the test procedures should be accepted if the aeroplane follows a steady glide path angle of $3^{\circ} \pm 0.5^{\circ}$.
- 5.7.6 If equivalent test procedures different from the reference procedures are used, the test procedures and all methods for adjusting the results to the reference procedures should be approved by the certifying authority. The amounts of the adjustments should not exceed 16 EPNdB on take-off and 8 EPNdB on approach, and if the adjustments are more than 8 EPNdB and 4 EPNdB, respectively, the resulting numbers should not be within 2 EPNdB of the limit noise levels specified in

Note.- Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.

CHAPTER 6. Blank.

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CHAPTER 7. PROPELLER-DRIVEN STOL AEROPLANES

Note- *Standards and Recommended Practices for this chapter are not yet developed. In the meantime, guidelines provided in Attachment B may be used for noise certification of propeller-driven STOL aeroplanes for which a certificate of airworthiness for the individual aeroplane was first issued on or after 1 January 1976.*

CHAPTER 8. HELICOPTERS

8.1 Applicability

Note- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

- 8.1.1 The Standards of this chapter should be applicable to all helicopters for which 8.1.2, 8.1.3 and 8.1.4 apply, except those specifically designed and used for agricultural, firefighting or external load-carrying purposes.
- 8.1.2 For a helicopter for which the application for the Type Certificate was submitted on or after 1 January 1985, except for those helicopters specified in 8.1.4, the maximum noise levels of 8.4.1 should apply.
- 8.1.3 For a derived version of a helicopter for which the application for certification of the change in type design was submitted on or after 17 November 1988, except for those helicopters specified in 8.1.4, the maximum noise levels of 8.4.1 should apply.
- 8.1.4 For all helicopters, including their derived versions, for which the application for the Type Certificate was submitted on or after 21 March 2002, the maximum noise levels of 8.4.2 should apply.
- 8.1.5 Certification of helicopters which are capable of carrying external loads or external equipment should be made without such loads or equipment fitted.

Note.-Helicopters which comply with the Standards with internal loads may be exempted when carrying external loads or external equipment, if such operations are conducted at a gross mass or with other operating parameters which are in excess of those certificated for airworthiness with internal loads.

- 8.1.6 An applicant under 8.1.1 may alternatively elect to show compliance with Chapter 11 instead of Chapter 8 if the helicopter has a maximum certificated take-off mass of 3 175 kg or less.

8.2 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2.

8.3 Reference noise measurement points

A helicopter, when tested in accordance with these Standards, should not exceed the noise levels specified in 8.4 at the following points:

- a) *Take-off reference noise measurement points*
- 1) a flight path reference point located on the ground vertically below the flight path defined in the take-off reference procedure and 500 m horizontally in the direction of flight from the point at which transition to climbing flight is

initiated in the reference procedure (see 8.6.2);

- 2) two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the take-off reference procedure and lying on a line through the flight path reference point.
- b) *Overflight reference noise measurement points*
- 1) a flight path reference point located on the ground 150 m (492 ft) vertically below the flight path defined in the overflight reference procedure (see 8.6.3.1);
 - 2) two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the overflight reference procedure and lying on a line through the flight path reference point.
- c) *Approach reference noise measurement points*
- 1 a flight path reference point located on the ground 120 m (394 ft) vertically below the flight path defined in the approach reference procedure (see 8.6.4). On level ground, this corresponds to a position 1140 m from the intersection of the 6.0° approach path with the ground plane;
 - 2 two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the approach reference procedure and lying on a line through the flight path reference point.


Note- See Attachment H (Guidelines for Obtaining Helicopter Noise Data for Land-use Planning Purposes) that defines acceptable supplemental land-use planning (LUP) data procedures.

8.4 Maximum noise levels

8.4.1 For helicopters specified in 8.1.2 and 8.1.3, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed the following:

8.4.1.1 For take-off: 109 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 89 EPNdB after which the limit is constant.

8.4.1.2 For overflight: 108 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 88 EPNdB after which the limit is constant.

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8.4.1.3 For approach: 110 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 90 EPNdB after which the limit is constant.

Note- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

8.4.2 For helicopters specified in 8.1.4, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed the following:

8.4.2.1 For take-off: 106 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 86 EPNdB after which the limit is constant.

8.4.2.2 For overflight: 104 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 84 EPNdB after which the limit is constant.

8.4.2.3 For approach: 109 EPNdB for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the helicopter mass at a rate of 3 EPNdB per halving of mass down to 89 EPNdB after which the limit is constant.

8.5 Trade-offs

If the noise level limits are exceeded at one or two measurement points:

- a) the sum of excesses should not be greater than 4 EPNdB;
- b) any excess at any single point should not be greater than 3 EPNdB; and
- c) any excess should be offset by corresponding reductions at the other point or points.

8.6 Noise certification reference procedures

8.6.1 General conditions

8.6.1.1 The reference procedures should comply with the appropriate airworthiness requirements.

8.6.1.2 The reference procedures and flight paths should be approved by the certifying

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authority.

8.6.1.3 Except in conditions specified in 8.6.1.4, the take-off, overflight and approach reference procedures should be those defined in 8.6.2, 8.6.3 and 8.6.4, respectively.

8.6.1.4 When it is shown by the applicant that the design characteristics of the helicopter would prevent flight being conducted in accordance with 8.6.2, 8.6.3 or 8.6.4, the reference procedures should:

- a) depart from the reference procedures defined in 8.6.2, 8.6.3 or 8.6.4 only to the extent demanded by those design characteristics which make compliance with the reference procedures impossible; and
- b) be approved by the certifying authority.

8.6.1.5 The reference procedures should be established for the following reference atmospheric conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 25°C, i.e. ISA + 10°C;
- c) relative humidity of 70 per cent; and
- d) zero wind.

8.6.1.6 In 8.6.2 c), 8.6.3.1 c) and 8.6.4 c), the maximum normal operating rpm should be taken as the highest rotor speed for each reference procedure corresponding to the airworthiness limit imposed by the manufacturer and approved by the certifying authority. Where a tolerance on the highest rotor speed is specified, the maximum normal operating rotor speed should be taken as the highest rotor speed about which that tolerance is given. If the rotor speed is automatically linked with flight condition, the maximum normal operating rotor speed corresponding with the reference flight condition should be used during the noise certification procedure. If rotor speed can be changed by pilot action, the maximum normal operating rotor speed specified in the flight manual limitation section for the reference conditions should be used during the noise certification procedure.

8.6.2 Take-off reference procedure

The take-off reference flight procedure should be established as follows:

- a) the helicopter should be stabilized at the maximum take-off power corresponding to minimum installed engine(s) specification power available for the reference ambient conditions or gearbox torque limit, whichever is lower, and along a path starting from a point located 500 m prior to the flight path reference point, at 20

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m (65 ft) above the ground;

- b) the best rate of climb speed, V_Y , or the lowest approved speed for the climb after take-off, whichever is the greater, should be maintained throughout the take-off reference procedure;
- c) the steady climb should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for take-off;
- d) a constant take-off configuration selected by the applicant should be maintained throughout the take-off reference procedure with the landing gear position consistent with the airworthiness certification tests for establishing the best rate of climb speed, V_Y ;
- e) the mass of the helicopter should be the maximum take-off mass at which noise certification is requested; and
- f) the reference take-off path shall be a straight-line segment inclined from the starting point (500 m prior to the center microphone location and 20 m (65 ft) above ground level) at an angle defined by best rate of climb and V_Y for minimum specification engine performance.

8.6.3 Overflight reference procedure

8.6.3.1 The overflight reference procedure should be established as follows:

- a) the helicopter should be stabilized in level flight overhead the flight path reference point at a height of 150 m (492 ft);
- b) a speed of $0.9 V_H$ or $0.9 V_{NE}$ or $0.45 V_H + 120 \text{ km/h}$ ($0.45 V_H + 65 \text{ kt}$) or $0.45 V_{NE} + 120 \text{ km/h}$ ($0.45 V_{NE} + 65 \text{ kt}$), whichever is the least, should be maintained throughout the overflight reference procedure;

Note- For noise certification purposes, V_H is defined as the airspeed in level flight obtained using the torque corresponding to minimum engine installed, maximum continuous power available for sea level pressure (1 013.25 hPa), 25°C ambient conditions at the relevant maximum certificated mass. V_{NE} is defined as the not-to-exceed airworthiness airspeed imposed by the manufacturer and approved by the certifying authority.

- c) the overflight should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for level flight;
- d) the helicopter should be in the cruise configuration; and
- e) the mass of the helicopter should be the maximum take-off mass at which noise certification is requested. 8.6.3.2 The value of V_H and/or V_{NE} used for noise certification should be quoted in the approved flight manual.

8.6.4 Approach reference procedure

The approach reference procedure should be established as follows:

- a) the helicopter should be stabilized and following a 6.0° approach path;
- b) the approach should be made at a stabilized airspeed equal to the best rate of climb speed, V_y , or the lowest approved speed for the approach, whichever is the greater, with power stabilized during the approach and over the flight path reference point, and continued to a normal touchdown;
- c) the approach should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, should be maintained throughout the approach reference procedure; and
- e) the mass of the helicopter at touchdown should be the maximum landing mass at which noise certification is requested.

8.7 Test procedures

- 8.7.1 The test procedures should be acceptable to the airworthiness and noise certifying authority of the State issuing the certificate.
- 8.7.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated as effective perceived noise level, EPNL, in units of EPNdB, as described in Appendix 2.
- 8.7.3 Test conditions and procedures should be closely similar to reference conditions and procedures or the acoustic data should be adjusted, by the methods outlined in Appendix 2, to the reference conditions and procedures specified in this chapter.
- 8.7.4 Adjustments for differences between test and reference flight procedures should not exceed:
 - a) *for take-off*: 4.0 EPNdB, of which the arithmetic sum of L_1 and the term $-7.5 \log(QK/Q_r K_r)$ from L_2 should not in total exceed 2.0 EPNdB;
 - b) *for overflight or approach*: 2.0 EPNdB.
- 8.7.5 During the test the average rotor rpm should not vary from the normal maximum operating rpm by more than ± 1.0 per cent during the 10 dB-down period.
- 8.7.6 The helicopter airspeed should not vary from the reference airspeed appropriate to the flight demonstration by more than ± 9 km/h (± 5 kt) throughout the 10 dB-down period.
- 8.7.7 The number of level overflights made with a headwind component should be equal to the number of level overflights made with a tailwind component.



- 8.7.8 The helicopter should fly within $\pm 10^\circ$ or ± 20 m, whichever is greater, from the vertical above the reference track throughout the 10 dB-down period (see Figure 8-1).

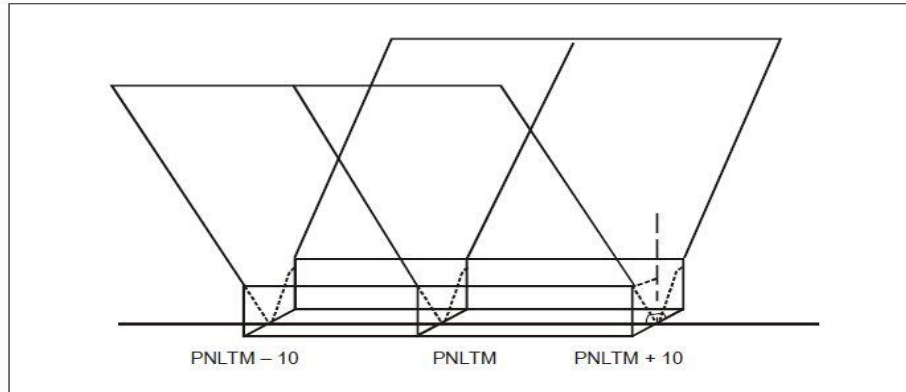



Figure 8-1. Helicopter lateral deviation tolerances

- 8.7.9 The helicopter height should not vary during overflight from the reference height at the overhead point by more than ± 9 m (± 30 ft).
- 8.7.10 During the approach noise demonstration the helicopter should be established on a stabilized constant speed approach within the airspace contained between approach angles of 5.5° and 6.5° .
- 8.7.11 Tests should be conducted at a helicopter mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per cent of the relevant maximum certificated mass. For each of the three flight conditions, at least one test shall be completed at or above this maximum certificated mass.

Note.-Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.


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CHAPTER 9. INSTALLED AUXILIARY POWER UNITS (APU) AND ASSOCIATED AIRCRAFT SYSTEMS DURING GROUND OPERATIONS

Note- *Standards and Recommended Practices for this chapter are not yet developed. In the meantime, guidelines provided in Attachment C may be used for noise certification of installed auxiliary power units (APU) and associated aircraft systems in:*

- a) *all aircraft for which the application for a Type Certificate was submitted, or another equivalent prescribed procedure was carried out by the certifying authority, on or after 6 October 1977; and*

- b) *aircraft of existing type design for which the application for a change of type design involving the basic APU installation was submitted, or another equivalent prescribed procedure was carried out by the certifying authority, on or after 6 October 1977.*

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CHAPTER 10. PROPELLER-DRIVEN AEROPLANES NOT EXCEEDING 8618 kg - Application for Type Certificate or Certification of Derived Version submitted on or after 17 November 1988

10.1 Applicability

Note 1.- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

Note 2.- See Attachment E for guidance on interpretation of these applicability provisions.

- 10.1.1 The Standards of this chapter should be applicable to all propeller-driven aeroplanes with a certificated take-off mass not exceeding 8618 kg, except those aeroplanes specifically designed and used for aerobatic, agricultural or firefighting purposes and self-sustaining powered sailplanes.
- 10.1.2 For aeroplanes for which the application for the Type Certificate was submitted on or after 17 November 1988, except for those aeroplanes specified in 10.1.6, the maximum noise levels of 10.4 a) should apply.
- 10.1.3 For aeroplanes specified in 10.1.2 where the application for the Type Certificate was submitted before 17 November 1993 and which fail to comply with the Standards of this chapter, the Standards of Chapter 6 should apply.
- 10.1.4 For derived versions for which the application for certification of the change in type design was submitted on or after 17 November 1988, except for those derived versions specified in 10.1.6, the maximum noise levels of 10.4 a) should apply.
- 10.1.5 For derived versions specified in 10.1.4 where the application for certification of the change in type design was submitted before 17 November 1993 and which fail to comply with the Standards of this chapter, the Standards of Chapter 6 should apply.
- 10.1.6 For single-engine aeroplanes, except float planes and amphibians:
- a) the maximum noise levels of 10.4 b) should apply to those aeroplanes, including their derived versions, for which the application for the Type Certificate was submitted on or after 4 November 1999;
 - b) the maximum noise levels of 10.4 b) should apply to those derived versions of aeroplanes for which the application for the Type Certificate was submitted before 4 November 1999 and for which the application for certification of the change in type design was submitted on or after 4 November 1999; except
 - c) for those derived versions described in 10.1.6 b) where the application for certification of the change in type design was submitted before 4 November 2004 and which exceed the maximum noise levels of 10.4 b), in which case the maximum noise levels of 10.4 a) should apply.

10.2 Noise evaluation measure

The noise evaluation measure should be the maximum A-weighted noise level (L_{Amax}) as defined in Appendix 6.

10.3 Reference noise measurement points

10.3.1 An aeroplane, when tested in accordance with these Standards, should not exceed the noise level specified in 10.4 at the take-off reference noise measurement point.

10.3.2 The take-off reference noise measurement point shall be the point on the extended center line of the runway at a distance of 2500 m from the start of take-off roll.

10.4 Maximum noise levels

The maximum noise levels determined in accordance with the noise evaluation method of Appendix 6 should not exceed the following:

- a) for aeroplanes specified in 10.1.2 and 10.1.4, a 76 dB(A) constant limit up to an aeroplane mass of 600 kg varying linearly from that point with the logarithm of aeroplane mass until at 1400 kg the limit of 88 dB(A) is reached after which the limit is constant up to 8618 kg; and
- b) for aeroplanes specified in 10.1.4, a 70 dB(A) constant limit up to an aeroplane mass of 570 kg increasing linearly from that point with the logarithm of aeroplane mass until at 1500 kg the limit of 85 dB(A) is reached after which the limit is constant up to 8618 kg.

Note -See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

10.5 Noise certification reference procedures

10.5.1 General conditions


10.5.1.1 The calculations of reference procedures and flight paths should be approved by the certifying authority.

10.5.1.2 Except in conditions specified in 10.5.1.3, the take-off reference procedure should be that defined in 10.5.2.

10.5.1.3 When it is shown by the applicant that the design characteristics of the aeroplane would prevent flights being conducted in accordance with 10.5.2, the reference procedures should:

- a) depart from the reference procedures defined only to the extent demanded by those design characteristics which make compliance with the procedures impossible; and
- b) be approved by the certifying authority.

10.5.1.4 The reference procedures should be calculated under the following atmospheric

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conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 15°C, i.e. ISA;
- c) relative humidity of 70 per cent; and
- d) zero wind.

10.5.1.5 The acoustic reference atmospheric conditions should be the same as the reference atmospheric conditions for flight.

10.5.2 Take-off reference procedure

The take-off flight path should be calculated taking into account the following two phases.

First phase

- a) take-off power should be used from the brake release point to the point at which the height of 15 m (50 ft) above the runway is reached;
- b) a constant take-off configuration selected by the applicant should be maintained throughout this first phase;
- c) the mass of the aeroplane at the brake release should be the maximum take-off mass at which the noise certification is requested; and
- d) the length of this first phase should correspond to the length given in the airworthiness data for a take-off on a level paved runway.

Second phase


- a) the beginning of the second phase corresponds to the end of the first phase;
- b) the aeroplane should be in the climb configuration with landing gear up, if retractable, and flap setting corresponding to normal climb throughout this second phase;
- c) the speed should be the best rate of climb speed, V_y ; and
- d) take-off power and, for aeroplanes equipped with variable pitch or constant speed propellers, rpm should be maintained throughout the second phase. If airworthiness limitations do not permit the application of take-off power and rpm up to the reference point, then take-off power and rpm should be maintained for as long as is permitted by such limitations and thereafter at maximum continuous power and rpm. Limiting of time for which take-off power and rpm should be used in order to comply with this chapter should not be permitted. The reference height should be calculated assuming climb gradients appropriate to each power setting used.

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10.6 Test procedures

- 10.6.1 The test procedures should be acceptable to the airworthiness and noise certifying authorities of the State issuing the certificate.
- 10.6.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure in units of L_{Amax} as described in Appendix 6.
- 10.6.3 Acoustic data should be adjusted by the methods outlined in Appendix 6 to the reference conditions specified in this chapter.
- 10.6.4 If equivalent test procedures are used, the test procedures and all methods for correcting the results to the reference procedures should be approved by the certifying authority.

Note- *Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.*

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CHAPTER 11. HELICOPTERS NOT EXCEEDING 3175 kg MAXIMUM CERTIFICATED TAKE-OFF MASS

11.1 Applicability

Note- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

- 11.1.1 The Standards of this chapter should be applicable to all helicopters having a maximum certificated take-off mass not exceeding 3175 kg for which 11.1.2, 11.1.3 and 11.1.4 apply, except those specifically designed and used for agricultural, firefighting or external load-carrying purposes.
- 11.1.2 For a helicopter for which the application for the Type Certificate was submitted on or after 11 November 1993, except for those helicopters specified in 11.1.4, the maximum noise levels of 11.4.1 should apply.
- 11.1.3 For a derived version of a helicopter for which the application for certification of the change in type design was submitted on or after 11 November 1993, except for those helicopters specified in 11.1.4, the maximum noise levels of 11.4.1 should apply.
- 11.1.4 For all helicopters, including their derived versions, for which the application for the Type Certificate was submitted on or after 21 March 2002, the maximum noise levels of 11.4.2 should apply.
- 11.1.5 Certification of helicopters which are capable of carrying external loads or external equipment should be made without such loads or equipment fitted.

Note- Helicopters which comply with the Standards with internal loads may be excepted when carrying external loads or external equipment, if such operations are conducted at a gross mass or with other operating parameters which are in excess of those certificated for airworthiness with internal loads.
- 11.1.6 An applicant under 11.1.1, 11.1.2, 11.1.3 and 11.1.4 may alternatively elect to show compliance with Chapter 8 instead of complying with this chapter.

11.2 Noise evaluation measure

The noise evaluation measure should be the sound exposure level L_{AE} as described in Appendix 4.

11.3 Reference noise measurement point

A helicopter, when tested in accordance with these Standards, should not exceed the noise levels specified in 11.4 at a flight path reference point located on the ground 150 m (492 ft) vertically below the flight path defined in the overflight reference procedure

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(see 11.5.2.1).

Note- See Attachment H (Guidelines for Obtaining Helicopter Noise Data for Land-use Planning Purposes) that defines acceptable supplemental land-use planning (LUP) data procedures.

11.4 Maximum noise level

11.4.1 For helicopters specified in 11.1.2 and 11.1.3, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 4, should not exceed 82 dB(A) for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of up to 788 kg and increasing linearly with the logarithm of the helicopter mass at a rate of 3 decibels per doubling of mass thereafter.

11.4.1 For helicopters specified in 11.1.4, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 4, should not exceed 82 dB(A) for helicopters with maximum certificated take-off mass, at which the noise certification is requested, of up to 1417 kg and increasing linearly with the logarithm of the helicopter mass at a rate of 3 decibels per doubling of mass thereafter.

Note- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

11.5 Noise certification reference procedure

11.5.1 General conditions

11.5.1.1 The reference procedure should comply with the appropriate airworthiness requirements and should be approved by the certifying authority.

11.5.1.2 Except as otherwise approved, the overflight reference procedure should be as defined in 11.5.2.

11.5.1.3 When it is shown by the applicant that the design characteristics of the helicopter would prevent flight being conducted in accordance with 11.5.2 the reference procedure should be permitted to depart from the standard reference procedure, with the approval of the certifying authority, but only to the extent demanded by those design characteristics which make compliance with the reference procedures impossible.

11.5.1.4 The reference procedure should be established for the following reference atmospheric conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 25°C;
- c) relative humidity of 70 per cent; and

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d) zero wind.

11.5.1.5 The maximum normal operating rpm should be taken as the highest rotor speed corresponding to the airworthiness limit imposed by the manufacturer and approved by the certificating authority for overflight. Where a tolerance on the highest rotor speed is specified, the maximum normal operating rotor speed should be taken as the highest rotor speed about which that tolerance is given. If rotor speed is automatically linked with flight condition, the maximum normal operating rotor speed corresponding with the reference flight condition should be used during the noise certification procedure. If rotor speed can be changed by pilot action, the maximum normal operating rotor speed specified in the flight manual limitation section for the reference conditions should be used during the noise certification procedure.

11.5.2 Reference procedure

11.5.2.1 The reference procedure should be established as follows:

- a) the helicopter should be stabilized in level flight overhead the flight path reference point at a height of 150 m ± 15 m (492 ft ± 50 ft);
- b) a speed of 0.9 V_H or 0.9 V_{NE} or 0.45 V_H + 120 km/h (65 kt) or 0.45 V_{NE} + 120 km/h (65 kt), whichever is the least, should be maintained throughout the overflight procedure. For noise certification purposes, V_H is defined as the airspeed in level flight obtained using the torque corresponding to minimum engine installed, maximum continuous power available for sea level pressure (1013.25 hPa), 25°C ambient conditions at the relevant maximum certificated mass. V_{NE} is defined as the not-to-exceed airworthiness airspeed imposed by the manufacturer and approved by the certificating authority;
- c) the overflight should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for level flight;
- d) the helicopter should be in the cruise configuration; and
- e) the mass of the helicopter should be the maximum take-off mass at which noise certification is requested.

11.5.2.2 The value of V_H and/or V_{NE} used for noise certification should be quoted in the approved flight manual.


11.6 Test procedures

11.6.1 The test procedures should be acceptable to the airworthiness and noise certificating authorities of the State issuing the certificate.

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- 11.6.2 The test procedure and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated as sound exposure level (L_{AE}), in A-weighted decibels integrated over the duration time, as described in Appendix 4.
- 11.6.3 Test conditions and procedures should be closely similar to reference conditions and procedures or the acoustic data should be adjusted, by the methods outlined in Appendix 4, to the reference conditions and procedures specified in this chapter.
- 11.6.4 During the test, flights should be made in equal numbers with tailwind and headwind components.
- 11.6.5 Adjustments for differences between test and reference flight procedures should not exceed 2.0 dB(A).
- 11.6.6 During the test, the average rotor rpm should not vary from the normal maximum operating rpm by more than ±1.0 per cent during the 10 dB-down period.
- 11.6.7 The helicopter airspeed should not vary from the reference airspeed appropriate to the flight demonstration as described in Appendix 4 by more than ±5.5 km/h (±3 kt) throughout the 10 dB-down period.
- 11.6.8 The helicopter should fly within ±10° from the vertical above the reference track through the reference noise measurement position.
- 11.6.9 Tests should be conducted at a helicopter mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per cent of the relevant maximum certificated mass.

Note-Guidance material on the use of equivalent procedures is provided in the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft.

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CHAPTER 13. TILT-ROTORS

Note- These Standards are not sufficient to be used for tilt-rotors that also have one or more configurations that are certificated for airworthiness for STOL only. In such cases, different or additional procedures/conditions would likely be needed.

13.1 Applicability

Note- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

13.1.1 The Standards of this chapter should be applicable to all tilt-rotors, including their derived versions, for which the application for a Type Certificate was submitted on or after 1 January 2018.

13.1.2 Noise certification of tilt-rotors which are capable of carrying external loads or external equipment should be made without such loads or equipment fitted.

13.2 Noise evaluation measure

13.2.1 The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2 of this Part. The correction for spectral irregularities should start at 50 Hz (see 4.3.1 of Appendix 2).

13.2.2 Additional data in L_{AE} and L_{Amax} as defined in Appendix 4, and one-third octave SPLs as defined in Appendix 2 corresponding to L_{Amax} should be made available to the certificating authority for land-use planning purposes.

13.3 Noise measurement reference points

A tilt-rotor, when tested in accordance with the reference procedures of Section 6 and the test procedures of Section 7, should not exceed the noise levels specified in 13.4 at the following reference points:

a) *Take-off reference noise measurement points:*

- 1) A flight path reference point located on the ground vertically below the flight path defined in the take-off reference procedure (see 13.6.2) and 500 m (1 640 ft) horizontally in the direction of flight from the point at which transition to climbing flight is initiated in the reference procedure;
- 2) Two other points on the ground symmetrically disposed at 150 m (492 ft) on both sides of the flight path defined in the take-off reference procedure and lying on a line through the flight path reference point.

b) *Overflight reference noise measurement points:*

- 1) A flight path reference point located on the ground 150 m (492 ft) vertically below the flight path defined in the overflight reference procedure (see

13.6.3);

- 2) Two other points on the ground symmetrically disposed at 150 m (492 ft) on both sides of the flight path defined in the overflight reference procedure and lying on a line through the flight path reference point.

c) *Approach reference noise measurement points:*

- 1) A flight path reference point located on the ground 120 m (394 ft) vertically below the flight path defined in the approach reference procedure (see 13.6.4). On level ground, this corresponds to a position 1140 m (3740 ft) from the intersection of the 6.0° approach path with the ground plane;
- 2) Two other points on the ground symmetrically disposed at 150 m (492 ft) on both sides of the flight path defined in the approach reference procedure and lying on a line through the flight path reference point.

13.4 Maximum noise levels

13.4.1 For tilt-rotors specified in 13.1, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2 for helicopters, should not exceed the following:

13.4.1.1 *For take-off:* 109 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 89 EPNdB after which the limit is constant.

13.4.1.2 *For overflight:* 108 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 88 EPNdB after which the limit is constant. VTOL/conversion mode shall be defined as all approved configurations and flight modes where the design operating rotor speed is that used for hover operations.

Note 1- *For the tilt-rotor in aeroplane mode, there is no maximum noise level.*

13.4.1.3 *For approach:* 110 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 90 EPNdB after which the limit is constant.

Note. *The equations for the calculation of noise levels as a function of take-off mass presented in Section 7 of Attachment A, for conditions described in Chapter 8, 8.4.1, are consistent with the maximum noise levels defined in 13.4.*

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13.5 Trade-offs

If the maximum noise levels are exceeded at one or two measurement points:

- a) the sum of excesses should not be greater than 4 EPNdB;
- b) any excess at any single point should not be greater than 3 EPNdB; and
- c) any excess should be offset by corresponding reductions at the other point or points.

13.6 Noise certification reference procedures

13.6.1 General conditions

13.6.1.1 The reference procedures should comply with the appropriate airworthiness requirements.

13.6.1.2 The reference procedures and flight paths should be approved by the certificating authority.

13.6.1.3 Except in conditions specified in 13.6.1.4, the take-off, overflight and approach reference procedures should be those defined in 13.6.2, 13.6.3 and 13.6.4, respectively.

13.6.1.4 When it is shown by the applicant that the design characteristics of the tilt-rotor would prevent a flight from being conducted in accordance with 13.6.2, 13.6.3 or 13.6.4, the reference procedures should:

- a) depart from the reference procedures defined in 13.6.2, 13.6.3 or 13.6.4 only to the extent demanded by those design characteristics which make compliance with the reference procedures impossible; and
- b) be approved by the certificating authority.

13.6.1.5 The reference procedures should be established for the following reference atmospheric conditions:

- a) sea level atmospheric pressure of 1013.25 hPa;
- b) ambient air temperature of 25°C, i.e. ISA + 10°C;
- c) relative humidity of 70 per cent; and
- d) zero wind.

13.6.1.6 In 13.6.2 d), 13.6.3 d) and 13.6.4 c), the maximum normal operating rpm should be

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taken as the highest rotor speed for each reference procedure corresponding to the airworthiness limit imposed by the manufacturer and approved by the certificating authority. Where a tolerance on the highest rotor speed is specified, the maximum normal operating rotor speed should be taken as the highest rotor speed about which that tolerance is given. If the rotor speed is automatically linked with the flight condition, the maximum normal operating rotor speed corresponding with the reference flight condition should be used during the noise certification procedure. If the rotor speed can be changed by pilot action, the maximum normal operating rotor speed specified in the flight manual limitation section for the reference conditions should be used during the noise certification procedure.

13.6.2 Take-off reference procedure

The take-off reference flight procedure should be established as follows:

- a) a constant take-off configuration, including nacelle angle, selected by the applicant should be maintained throughout the take-off reference procedure;
- b) the tilt-rotor should be stabilized at the maximum take-off power corresponding to minimum installed engine(s) specification power available for the reference ambient conditions or gearbox torque limit, whichever is lower, and along a path starting from a point located 500 m (1640 ft) prior to the flight path reference point, at 20 m (65 ft) above the ground;
- c) the nacelle angle and the corresponding best rate of climb speed, or the lowest approved speed for the climb after take-off, whichever is the greater, should be maintained throughout the take-off reference procedure;
- d) the steady climb should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for take-off;
- e) the mass of the tilt-rotor should be the maximum take-off mass at which noise certification is requested; and
- f) the reference take-off path is defined as a straight line segment inclined from the starting point (500 m (1640 ft) prior to the center noise measurement point and 20 m (65 ft) above ground level) at an angle defined by best rate of climb (BRC) and the best rate of climb speed corresponding to the selected nacelle angle and for minimum specification engine performance.

13.6.3 Overflight reference procedure

13.6.3.1 The overflight reference procedure should be established as follows:

- a) the tilt-rotor should be stabilized in level flight overhead the flight path reference point at a height of 150 m (492 ft);
- b) a constant configuration selected by the applicant should be maintained throughout the overflight reference procedures;
- c) the mass of the tilt-rotor should be the maximum take-off mass at which noise certification is requested;
- d) in the VTOL/conversion mode, the nacelle angle at the authorized fixed operation point that is closest to the lowest nacelle angle certificated for zero airspeed, a speed of $0.9V_{CON}$ and a rotor speed stabilized at the maximum normal operating rpm certificated for level flight should be maintained throughout the overflight reference procedure; V_{CON} shall be the maximum authorized speed for VTOL/conversion mode at a specific nacelle angle.
- e) in the aeroplane mode, the nacelles should be maintained on the down-stop throughout the overflight reference procedure, with:
 - 1) rotor speed stabilized at the rpm associated with the VTOL/conversion mode and a speed of $0.9V_{CON}$; and
 - 2) rotor speed stabilized at the normal cruise rpm associated with the aeroplane mode and at the corresponding $0.9V_{MCP}$ or $0.9V_{MO}$, whichever is lesser, certificated for level flight. V_{MCP} shall be the maximum operating limit airspeed for aeroplane mode corresponding to minimum engine installed, maximum continuous power (MCP) available for sea level pressure (1 013.25 hPa), 25°C ambient conditions at the relevant maximum certificated mass; and V_{MO} shall be the maximum operating (MO) limit airspeed that may not be deliberately exceeded

13.6.3.2 The values of V_{CON} and V_{MCP} or V_{MO} used for noise certification should be quoted in the approved flight manual.

13.6.4 Approach reference procedure

The approach reference procedure should be established as follows:

- a) the tilt-rotor should be stabilized and follow a 6.0° approach path;
- b) the approach should be in an airworthiness approved configuration in which maximum noise occurs, at a stabilized airspeed equal to the best rate of climb speed corresponding to the nacelle angle, or the lowest approved airspeed for the approach, whichever is the greater, and with power stabilized during the

approach and over the flight path reference point, and continued to a normal touchdown;

- c) the approach should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, should be maintained throughout the approach reference procedure; and
- e) the mass of the tilt-rotor at touchdown should be the maximum landing mass at which noise certification is requested.

13.7 Test procedures

13.7.1 The test procedures should be acceptable to the airworthiness and noise certifying authority of the State issuing the certificate.

13.7.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated in 13.2.

13.7.3 Test conditions and procedures should be similar to reference conditions and procedures or the acoustic data should be adjusted, by the methods outlined in Appendix 2 for helicopters, to the reference conditions and procedures specified in this chapter.

13.7.4 Adjustments for differences between test and reference flight procedures should not exceed:

- a) *for take-off*: 4.0 EPNdB, of which the arithmetic sum of Δ_1 and the term $-7.5 \log QK/Q_r K_r$ from Δ_2 should not in total exceed 2.0 EPNdB; and
- b) *for overflight or approach*: 2.0 EPNdB.

13.7.5 During the test the average rotor rpm should not vary from the normal maximum operating rpm by more than ± 1.0 per cent throughout the 10 dB-down period.


13.7.6 The airspeed of the tilt-rotor should not vary from the reference airspeed appropriate to the flight demonstration by more than ± 9 km/h (± 5 kt) throughout the 10 dB-down period.

13.7.7 The number of level overflights made with a headwind component should be equal to the number of level overflights made with a tailwind component.

13.7.8 The tilt-rotor should fly within $\pm 10^\circ$ or ± 20 m (± 65 ft), whichever is greater, from the

vertical above the reference track throughout the 10 dB-down period (see Figure 8-1).

- 13.7.9 The height of the tilt-rotor should not vary during overflight from the reference height throughout the 10 dB-down period by more than ± 9 m (± 30 ft).
- 13.7.10 During the approach noise demonstration the tilt-rotor should be established on a stabilized constant speed approach within the airspace contained between approach angles of 5.5° and 6.5° throughout the 10 dB-down period.
- 13.7.11 Tests shall be conducted at a tilt-rotor mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per cent of the relevant maximum certificated mass. For each of the flight conditions, at least one test shall be completed at or above this maximum certificated mass.

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CHAPTER 14.

14.1 Applicability

Note.- See also Chapter 1, 1.10, 1.11, 1.12 and 1.13.

14.1.1 The Standards of this chapter should, with the exception of those aeroplanes which require a runway¹ length of 610 m or less at maximum certificated mass for airworthiness or propeller-driven aeroplanes specifically designed and used for agricultural or firefighting purposes, be applicable to:

- a) all subsonic jet aeroplanes and propeller-driven aeroplanes, including their derived versions, with a maximum certificated take-off mass of 55000 kg and over for which the application for a Type Certificate was submitted on or after 31 December 2017;
- b) all subsonic jet aeroplanes, including their derived versions, with a maximum certificated take-off mass of less than 55000 kg for which the application for a Type Certificate was submitted on or after 31 December 2020;
- c) all propeller-driven aeroplanes, including their derived versions, with a maximum certificated take-off mass of over 8 618 kg and less than 55000 kg for which the application for a Type Certificate was submitted on or after 31 December 2020; and
- d) all subsonic jet aeroplanes and all propeller-driven aeroplanes certificated originally as satisfying Part 16, Volume I, Chapter 3, Chapter 4 or Chapter 5, for which recertification to Chapter 14 is requested.

Note- Guidance material on applications for recertification is provided in the Environmental Technical Manual (Doc 9501), Volume I — Procedures for Noise Certification of Aircraft.

14.1.2 Notwithstanding 14.1.1, it may be recognized by a Contracting State that the following situations for jet aeroplanes and propeller-driven aeroplanes over 8618 kg maximum certificated take-off mass on its registry do not require demonstration of compliance with the provisions of the Standards of part 16, Volume

1. With no stopway or clearway.
 - a) gear down flight with one or more retractable landing gear down during the entire flight;
 - b) spare engine and nacelle carriage external to the skin of the aeroplane (and return of the pylon or other external mount); and
 - c) time-limited engine and/or nacelle changes, where the change in type design

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specifies that the aeroplane may not be operated for a period of more than 90 days unless compliance with the provisions of Part 16, Volume I, is shown for that change in type design. This applies only to changes resulting from a required maintenance action.

14.2 Noise measurements

14.2.1 Noise evaluation measure

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2.

14.3 Reference noise measurement points

14.3.1 An aeroplane, when tested in accordance with these Standards, should not exceed the maximum noise level specified in 14.4 of the noise measured at the points specified in Chapter 3, 3.3.1 a), b) and c).

14.3.2 Test noise measurement points

The provisions of Chapter 3, 3.3.2, relating to test noise measurement points should apply.

14.4 Maximum noise levels

14.4.1 The maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed the following:

14.4.1.1 *At the lateral full-power reference noise measurement point* 103 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 400000 kg and over, decreasing linearly with the logarithm of the mass down to 94 EPNdB at 35000 kg, after which the limit is constant to 8618 kg, where it decreases linearly with the logarithm of the mass down to 88.6 EPNdB at 2000 kg, after which the limit is constant.

14.4.1.2 *At the flyover reference noise measurement point*

a) *Aeroplanes with two engines or less* 101 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 385000 kg and over, decreasing linearly with the logarithm of the mass at the rate of 4 EPNdB per halving of mass down to 89 EPNdB, after which the limit is constant to 8618 kg, where it decreases linearly with the logarithm of the mass at a rate of 4 EPNdB per halving of mass down to 2000 kg, after which the limit is constant.

b) *Aeroplanes with three engines*

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As a) but with 104 EPNdB for aeroplanes with maximum certificated take-off mass of 385000 kg and over.

c) *Aeroplanes with four engines or more*

As a) but with 106 EPNdB for aeroplanes with maximum certificated take-off mass of 385000 kg and over.

14.4.1.3 *At the approach reference noise measurement point* 105 EPNdB for aeroplanes with maximum certificated take-off mass, at which the noise certification is requested, of 280000 kg and over, decreasing linearly with the logarithm of the mass down to 98 EPNdB at 35000 kg, after which the limit is constant to 8618 kg, where it decreases linearly with the logarithm of the mass down to 93.1 EPNdB at 2000 kg, after which the limit is constant.

14.4.1.4 The sum of the differences at all three measurement points between the maximum noise levels and the maximum permitted noise levels specified in 14.4.1.1, 14.4.1.2 and 14.4.1.3, should not be less than 17 EPNdB.

14.4.1.5 The maximum noise level at each of the three measurement points should not be less than 1 EPNdB below the corresponding maximum permitted noise level specified in 14.4.1.1, 14.4.1.2 and 14.4.1.3.

Note- See Attachment A for equations for the calculation of maximum permitted noise levels as a function of take-off mass.

14.5 Noise certification reference procedures

The noise certification reference procedures should be as specified in Chapter 3, 3.6.

14.6 Test procedures

The test procedures should be as specified in Chapter 3, 3.7.

14.7 Recertification

For aeroplanes specified in 14.1.1 d), recertification should be granted on the basis that the evidence used to determine compliance with Chapter 14 is as satisfactory as the evidence associated with aeroplanes specified in 14.1.1 a), b) and c).

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PART III. NOISE MEASUREMENT FOR MONITORING PURPOSES

Note- *The following Recommendation has been developed to assist States that measure noise for monitoring purposes, until such time as agreement on a single method can be reached.*

Where the measurement of aircraft noise is made for monitoring purposes, the method of Appendix 5 should be used.

Note - *These purposes are described as including: monitoring compliance with and checking the effectiveness of such noise abatement requirements as may have been established for aircraft in flight or on the ground. An indication of the degree of correlation between values obtained by the method used for measuring noise for aircraft design purposes and the method(s) used for monitoring purposes would be necessary.*

PART IV. ASSESSMENT OF AIRPORT NOISE

Note- *The following have been developed for the purpose of promoting international communication between States that have adopted a variety of methods of assessing noise for land-use planning purposes.*

1. *Where international comparison of noise assessment around airports is undertaken, the methodology described in Method for Computing Noise Contours Around Airports (Doc 9911) should be used.*

2. *Contracting States that have not yet adopted, or are considering changing a national noise assessment methodology, should use the methodology described in Method for Computing Noise Contours Around Airports (Doc 9911).*

PART V. BALANCED APPROACH TO NOISE MANAGEMENT

Note 1- Provisions in Part II of this Part are aimed at noise certification which characterizes the maximum noise emitted by the aircraft. However, noise abatement procedures approved by national authorities and included in operations manuals allow a reduction of noise during aircraft operations.

Note 2- The balanced approach to noise management consists of identifying the noise problem at an airport and then analysing the various measures available to reduce noise through the exploration of four principal elements, namely reduction at source (addressed in Part II of this Part), land-use planning and management, noise abatement operational procedures and operating restrictions, with the goal of addressing the noise problem in the most cost-effective manner. All the elements of the balanced approach are addressed in the Guidance on the Balanced Approach to Aircraft Noise Management (ICAO Doc 9829).

1. Aircraft operating procedures for noise abatement should not be introduced unless the regulatory authority, based on appropriate studies and consultation, determines that a noise problem exists.
2. Aircraft operating procedures for noise abatement should be developed in consultation with operators that use the aerodrome concerned.
3. *The factors to be taken into consideration in the development of appropriate aircraft operating procedures for noise abatement should include the following:*
 - a) *the nature and extent of the noise problem including:*
 - 1) *the location of noise-sensitive areas; and*
 - 2) *critical hours;*
 - b) *the types of aircraft affected, including aircraft mass, aerodrome elevation, temperature considerations;*
 - c) *the types of procedures likely to be most effective;*
 - d) *obstacle clearances (PANS-OPS (Doc 8168), Volumes I and II); and*
 - e) *human performance in the application of the operating procedures.*

Note 1- See Part 6, Part I, Chapter 4, for aeroplane noise abatement KCASR operating procedures.

Note 2.- Guidance material on human performance can be found in the Human Factors Training Manual (Doc 9683).

4. *Although in most countries, land-use planning and management are the responsibility of national and/or local planning authorities rather than aviation authorities, ICAO has developed guidance material which should be used to assist planning authorities in taking appropriate measures to ensure compatible land -use management around airports to the benefit of both the airport and the surrounding communities (Airport Planning Manual, Part 2, (Doc 9184)).*

**APPENDIX 1. EVALUATION METHOD FOR NOISE CERTIFICATION
OF SUBSONIC JET AEROPLANES — Application for Type Certificate
submitted before 6 October 1977**

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5. REPORTING OF DATA TO THE CERTIFICATING AUTHORITY AND CORRECTING MEASURED DATA

5.1 General

Data representing physical measurements or corrections to measured data should be recorded in permanent form and appended to the record except that corrections to measurements for normal equipment response deviations need not be reported. All other corrections should be approved. Attempts should be made to keep to a minimum the individual errors inherent in each of the operations employed in obtaining the final data.

5.2 Data reporting

5.2.1 Measured and corrected sound pressure levels should be presented in one-third octave band levels obtained with equipment conforming to the Standards described in Section 3 of this appendix.

5.2.2 The type of equipment used for measurement and analysis of all acoustic aeroplane performance and meteorological data should be reported.

5.2.3 The following atmospheric environmental data, measured immediately before, after, or during each test at the observation points prescribed in Section 2 of this appendix should be reported:

- a) air temperature and relative humidity;
- b) maximum, minimum and average wind velocities;
- c) atmospheric pressure.

5.2.4 Comments on local topography, ground cover, and events that might interfere with sound recordings should be reported.

5.2.5 The following aeroplane information should be reported:

- a) type, model, serial numbers (if any) of aeroplane and engines;
- b) gross dimensions of aeroplane and location of engines;
- c) aeroplane gross mass for each test run;
- d) aeroplane configuration such as flap and landing gear position;
- e) indicated airspeed in kilometres per hour (knots);

- f) engine performance in terms of net thrust, engine pressure ratios, jet exhaust temperatures and fan or compressor shaft rotational speeds as determined from aeroplane instruments and manufacturer’s data;
- g) aeroplane height above ground determined by a method independent of cockpit instrumentation, such as radar tracking, theodolite triangulation or photographic scaling techniques, to be approved by the certifying authorities.

5.2.6 Aeroplane speed and position and engine performance parameters should be recorded at an approved sampling rate sufficient to correct to the noise certification reference conditions prescribed in this section and should be synchronized with the noise measurement.

5.2.6.1 Lateral position relative to the extended center line of the runway, configuration and gross mass should be reported.


5.3 Noise certification reference conditions

Aeroplane position and performance data and the noise measurements should be corrected to the following noise certification reference conditions:

- a) meteorological conditions:
 - 1) sea level atmospheric pressure of 1013.25 hPa;
 - 2) ambient air temperature of 25°C, i.e. ISA + 10°C except that, at the discretion of the certifying authority, an alternative reference ambient air temperature of 15°C, i.e. ISA may be used;
 - 3) relative humidity of 70 per cent; and
 - 4) zero wind;
- b) aeroplane conditions:
 - 1) maximum take-off mass and landing mass at which noise certification is requested;
 - 2) approach angle of 3°; and
 - 3) aeroplane height of 120 m (394 ft) above the approach noise measuring station.

5.4 Data correction

5.4.1 The noise data should be corrected to the noise certification reference conditions as stated in 5.3. The measured atmospheric conditions should be those obtained in

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accordance with Section 2 of this appendix. Atmospheric attenuation of sound requirements are given in Section 8 of this appendix. If a reference ambient air temperature of 15°C is used (see 5.3 a) 2)), a further correction of +1 EPNdB should be added to the noise levels obtained at the flyover measurement point.

5.4.2 The measured flight path should be corrected by an amount equal to the difference between the applicant’s predicted flight paths for the test conditions and for the noise certification reference conditions.

Note.- Necessary corrections relating to aeroplane flight path or performance may be derived from approved data other than certification test data.

5.4.2.1 The flight path correction procedure for approach noise should be made with reference to a fixed aeroplane reference height and the reference approach angle. The effective perceived noise level correction should be less than 2 EPNdB to allow for:

- a) the aeroplane not passing vertically above the measuring point;
- b) the difference between the reference height and the height of the aeroplane’s ILS antenna from the approach measuring point; and
- c) the difference between the reference and the test approach angles.

Note- Detailed correction requirements are given in Section 9 of this appendix.

5.4.3 Test results on specific measurement should not be accepted if the difference in EPNL computed from measured data and that corrected to reference conditions exceeds 15 EPNdB.


5.4.4 If aeroplane sound pressure levels do not exceed the ambient sound pressure levels by at least 10 dB in any one-third octave band, approved corrections for the contribution of ambient sound pressure level to the observed sound pressure level should be applied.

5.5 Validity of results

5.5.1 Three average EPNL values and their 90 per cent confidence limits should be produced from the test results, each such value being the arithmetical average of the corrected acoustical measurements for all valid test runs at the appropriate measurement point (take-off, approach or sideline). If more than one acoustic measurement system is used at any single measurement location (such as for the symmetrical sideline measuring points), the resulting data for each test run should be averaged as a single measurement.

5.5.2 The minimum sample size acceptable for each of the three certification measuring

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points should be six. The samples should be large enough to establish statistically for each of the three average noise certification levels a 90 per cent confidence limit not exceeding ± 1.5 EPNdB. No test result should be omitted from the average process unless otherwise specified by the certifying authorities.

- 5.5.3 The average EPNL values and their 90 per cent confidence limits obtained by the foregoing process should be those by which the noise performance of the aeroplane is assessed against the noise certification criteria, and should be reported.

6. NOMENCLATURE

6.1 Symbols and units

Note- The meanings of the various symbols in this appendix are as follows. It is recognized that differences may exist in the units and meanings of similar symbols in Appendix 2.

<i>Symbol</i>	<i>Unit</i>	<i>Meaning</i>
antilog	—	<i>Antilogarithm to the base 10.</i>
C(k)	dB	<i>Tone correction factor. The factor to be added to PNL(k) to account for the presence of spectral irregularities such as tones at the k-th increment of time.</i>
d	s	<i>Duration time. The length of the significant noise time history being the time interval between the limits of t(1) and t(2) to the nearest second.</i>
D	dB	<i>Duration correction. The factor to be added to PNLTM to account for the duration of the noise.</i>
EPNL	EPNdB	<i>Effective perceived noise level. The value of PNL adjusted for both the spectral irregularities and the duration of the noise. (The unit EPNdB is used instead of the unit dB.)</i>
f(i)	Hz	<i>Frequency. The geometrical mean frequency for the i-th one-third octave band.</i>
F(i,k)	dB	<i>Delta-dB. The difference between the original sound pressure level and the final background sound pressure level in the i-th one-third octave band at the k-th interval of time</i>
h	dB	<i>dB-down. The level to be subtracted from PNLTM that defines the duration of the noise.</i>
H	%	<i>Relative humidity. The ambient atmospheric relative humidity.</i>
i	—	<i>Frequency band index. The numerical indicator that denotes any one of the 24 one-third octave bands with geometrical mean frequencies from 50 to 10000 Hz.</i>
k	—	<i>Time increment index. The numerical indicator that denotes the number of equal time increments that have elapsed from a reference zero.</i>
log	—	<i>Logarithm to the base 10.</i>
log n(a)	—	<i>Noy discontinuity coordinate. The log n value of the intersection point of the straight lines representing the variation of SPL with log n.</i>

M(b), M(c), etc.	—	Noy inverse slope. The reciprocals of the slopes of straight lines representing the variation of SPL with log n.
n	noy	Perceived noisiness. The perceived noisiness at any instant of time that occurs in a specified frequency range.
n(i,k)	noy	Perceived noisiness. The perceived noisiness at the k-th instant of time that occurs in the i-th one-third octave band.
n(k)	noy	Maximum perceived noisiness. The maximum value of all of the 24 values of n(i) that occurs at the k-th instant of time.
N(k)	noy	Total perceived noisiness. The total perceived noisiness at the k-th instant of time calculated from the 24 instantaneous values of n(i,k).
p(b), p(c), etc.	—	Noy slope. The slopes of straight lines representing the variation of SPL with log n.
PNL	PNdB	Perceived noise level. The perceived noise level at any instant of time. (The unit PNdB is used instead of the unit dB.)
PNL(k)	PNdB	Perceived noise level. The perceived noise level calculated from the 24 values of SPL(i,k) -th increment of time. (The unit PNdB is used instead of the unit dB.)
PNLM	PNdB	Maximum perceived noise level. The maximum value of PNL(k). (The unit PNdB is used of the unit dB.)
PNLT	TPNdB	Tone corrected perceived noise level. The value of PNL adjusted for the spectral irregularities that occur at any instant of time. (The unit TPNdB is used instead of the unit dB.)
PNLT(k)	TPNdB	Tone corrected perceived noise level. The value of PNL(k) adjusted for the spectral irregularities that occur at the k-th increment of time. (The unit TPNdB is used instead of the unit dB.)
PNLTM	TPNdB	Maximum tone corrected perceived noise level. The maximum value of PNLT(k). (The unit TPNdB is used instead of the unit dB.)
s(i,k)	dB	Slope of sound pressure level. The change in level between adjacent one-third octave band sound pressure levels at the i-th band for the k-th instant of time.
s(i,k)	dB	Change in slope of sound pressure level.
s (i,k)	dB	Adjusted slope of sound pressure level. The change in level between adjacent adjusted one-third octave band sound pressure levels at the i-th band for the k-th instant of time.
(i,k)	dB	Average slope of sound pressure level.
SPL ⁻	dB re 20 μPa	Sound pressure level. The sound pressure level at any instant of time that occurs in a specified frequency range.

SPL(a)	dB re 20 μPa	Noy discontinuity coordinate. The SPL value of the intersection point of the straight lines representing the variation of SPL with log n.
SPL(b)	dB re	Noy intercept. The intercepts on the SPL-axis of the straight lines
SPL(c)	20 μPa	representing the variation of SPL with log n.
SPL(i,k)	dB re 20 μPa	Sound pressure level. The sound pressure level at the k-th instant of time that occurs in the i-th one-third octave band.
SPL (i,k)	dB re 20 μPa	Adjusted sound pressure level. The first approximation to background sound pressure level in the i-th one-third octave band for the k-th instant of time.
SPL(i)	dB re 20 μPa	Maximum sound pressure level. The sound pressure level that occurs in the i-th one-third octave band of the spectrum for PNLTM.
SPL(i)c	dB re 20 μPa	Corrected maximum sound pressure level. The sound pressure level that occurs in the i-th one-third octave band of the spectrum for PNLTM corrected for atmospheric sound absorption.
SPL (i,k)	dB re20 μPa	Final background sound pressure level. The second and final approximation to background sound pressure level in the i-th one-third octave band for the k-th instant of time
t	s	Elapsed time. The length of time measured from a reference zero.
t1, t2	s	Time limit. The beginning and end of the significant noise time history defined by h.
t	s	Time increment. The equal increments of time for which PNL(k) and PNLT(k) are calculated.
T	s	Normalizing time constant. The length of time used as a reference in the integration method for computing duration corrections, where T = 10 s.
t(°C)	°C	Temperature. The ambient atmospheric temperature.
α(i)	dB/100 m	Test atmospheric absorption. The atmospheric attenuation of sound that occurs in the i-th one-third octave band for the measured atmospheric temperature and relative humidity.
α(i)o	dB/100 m	Reference atmospheric absorption. The atmospheric attenuation of sound that occurs in the i-th one-third octave band for a reference atmospheric temperature and relative humidity.
β	degrees	First constant* climb angle.
γ	degrees	Second constant** climb angle.
δ	degrees	Thrust cutback angles. The angles defining the points on the take-off flight path at which

ϵ	degrees	thrust reduction is started and ended, respectively.
η	degrees	Approach angle.
η_r	degrees	Reference approach angle.
θ	degrees	Take-off noise angle. The angle between the flight path and noise path for take-off operations. It is identical for both measured and corrected flight paths.
λ	degrees	Approach noise angle. The angle between the flight path and the noise path for approach operations. It is identical for both measured and corrected flight paths.
$\Delta 1$	EPNdB	PNLT correction. The correction to be added to the EPNL calculated from measured data to account for noise level changes due to differences in atmospheric absorption and noise path length between reference and test conditions.
$\Delta 2$	EPNdB	Noise path duration correction. The correction to be added to the EPNL calculated from measured data to account for noise level changes due to the noise duration because of differences in flyover altitude between reference and test conditions.
$\Delta 3$	EPNdB	Mass correction. The correction to be added to the EPNL calculated from measured data to account for noise level changes due to differences between maximum mass and actual mass of the test aeroplane.

* Gear up, speed of at least $V_2 + 19$ km/h (V_2)

** Gear up, speed of at least $V_2 + 19$ km/h (V_2)

<i>Symbol</i>	<i>Unit</i>	<i>Meaning</i>
4	EPNdB	Approach angle correction. The correction to be added to the EPNL calculated from measured data to account for noise level changes due to differences between the reference and the test approach angles.
AB	metres	Take-off profile changes. The algebraic changes in the basic parameters defining the take-off profile due to differences between reference and test conditions.

- β degrees
- $\Delta\gamma$ degrees
- $\Delta\delta$ degrees
- $\Delta\epsilon$ degrees

6.2 Flight profile identification positions

Position Description

- e) Start of take-off roll.
- f) Lift-off.
- g) Start of first constant climb.
- h) Start of thrust reduction.
- E Start of second constant climb.
- E_c Start of second constant climb on corrected flight path.
- F End of noise certification take-off flight path.
- F_c End of noise certification corrected take-off flight path.
- G Start of noise certification approach flight path.
- G_r Start of noise certification approach on reference flight path.
- H Position on approach path directly above noise measuring station.
- H_r Position on reference approach path directly above noise measuring station.
- I Start of level-off.
- I_r Start of level-off on reference approach flight path.
- J Touchdown.
- K Flyover noise measurement point.
- L Lateral noise measurement point(s) (not on flight track).
- M End of noise certification take-off flight track.
- N Approach noise measurement point.
- O Threshold of approach end of runway.
- P Start of noise certification approach flight track.
- Q Position on measured take-off flight path corresponding to apparent PNLTM at station K. (See 9.2.) Q_c Position on corrected take-off flight path corresponding to PNLTM at station K. (See 9.2.)
- R Position on measured take-off flight path nearest to station K.

Position Description

R _c	Position on corrected take-off flight path nearest to station K.
S	Position on measured approach flight path corresponding to PNLTM at station N.
Sr	Position on reference approach flight path corresponding to PNLTM at station N.
T	Position on measured approach flight path nearest to station N.
Tr	Position on reference approach flight path nearest to station N.
X	Position on measured take-off flight path corresponding to PNLTM at station L.

6.3 Flight profile distances

<i>Distance</i>	<i>Unit</i>	<i>Meaning</i>
AB	metres	<i>Length of take-off roll.</i> The distance along the runway between the start of take-off roll and lift-off.
AK	metres	Take-off measurement distance. The distance from the start of roll to the take-off noise measurement station along the extended center line of the runway.
AM	metres	Take-off flight track distance. The distance from the start of roll to the take-off flight track position along the extended center line of the runway for which the position of the aeroplane need no longer be recorded.
KQ	metres	Measured take-off noise path. The distance from station K to the measured aeroplane position Q.
KQc	metres	Corrected take-off noise path. The distance from station K to the corrected aeroplane position Qc.
KR	metres	Measured take-off minimum distance. The distance from station K to point R on the measured flight path.
KRc	metres	Corrected take-off minimum distance. The distance from station K to point Rc on the corrected flight path.
LX	metres	Measured sideline noise path. The distance from station L to the measured aeroplane position X.
NH	Metres (feet)	Aeroplane approach height. The height of the aeroplane above the approach measuring station.
NHr	Metres (feet)	Reference approach height. The height of the reference approach path above the approach measuring station.
NS	metres	Measured approach noise path. The distance from station N to the measured aeroplane position S.
NSr	metres	Reference approach noise path. The distance from station N to the reference aeroplane position Sr.
NT	metres	Measured approach minimum distance. The distance from station N to point T on the measured flight path.
NTr	metres	Reference approach minimum distance. The distance from station N to point Tr on the corrected flight path.
ON	metres	Approach measurement distance. The distance from the runway threshold to the approach measurement station along the extended center line of the runway.
OP	metres	Approach flight track distance. The distance from the runway threshold to the approach

flight track position along the extended center line of the runway for which the position of the aeroplane need no longer be recorded.



7. MATHEMATICAL FORMULATION OF NOY TABLES

Note 1- The relationship between sound pressure level and perceived noisiness given in Table A1-1 is illustrated in Figure A1-3. The variation of SPL with $\log n$ for a given one-third octave band is expressed by either one or two straight lines depending upon the frequency range. Figure A1-3 a) illustrates the double line case for frequencies below 400 Hz and above 6 300 Hz and Figure A1-3 b) illustrates the single line case for all other frequencies.

The important aspects of the mathematical formulation are:

- the slopes of the straight lines $p(b)$ and $p(c)$;
- the intercepts of the lines on the SPL-axis, $SPL(b)$ and $SPL(c)$; and
- the coordinates of the discontinuity, $SPL(a)$ and $\log n(a)$.

Note 2.- Mathematically the relationship is expressed as follows:

Case 1: Figure A1-3 a): $f < 400$ Hz

$f > 6\ 300$ Hz

$$SPL(a) = \frac{p(c) SPL(b) - p(b) SPL(c)}{p(c) - p(b)}$$

$$p(c) - p(b)$$

$$\log n(a) = \frac{SPL(c) - SPL(b)}{p(b) - p(c)}$$

$$p(b) - p(c)$$

a) $SPL < SPL(a)$

$$n = \text{antilog} \frac{SPL - SPL(b)}{p(b)}$$

b) $SPL \geq SPL(a)$

$$n = \text{antilog} \frac{SPL - SPL(c)}{p(c)}$$

c) $\log n < \log n(a)$

$$SPL = p(b) \log n + SPL(b)$$

d) $\log n \geq \log n(a)$

$$SPL = p(c) \log n + SPL(c)$$

Case 2: Figure A1-3 b): $400 \leq f \leq 6\ 300$ Hz



$$n = \text{antilog } \frac{\text{SPL} - \text{SPL}(c)}{p(c)}$$

$$p(c)$$

$$\text{SPL} = p(c) \log n + \text{SPL}(c)$$

Note 3.- If the reciprocals of the slopes are defined as:

$$M(b) = 1/p(b)$$

$$M(c) = 1/p(c)$$

the equations in Note 2 can be written,

Case 1: Figure A1-3 a): $f < 400$ Hz

$$f > 6300 \text{ Hz}$$

$$\text{SPL}(a) = \frac{M(b) \text{SPL}(b) - M(c) \text{SPL}(c)}{M(b) - M(c)}$$

$$\log n(a) = \frac{M(b) M(c) [\text{SPL}(c) - \text{SPL}(b)]}{M(c) - M(b)}$$

a) $\text{SPL} < \text{SPL}(a)$

$$n = \text{antilog } M(b) [\text{SPL} - \text{SPL}(b)]$$

b) $\text{SPL} \geq \text{SPL}(a)$

$$n = \text{antilog } M(c) [\text{SPL} - \text{SPL}(c)]$$

c) $\log n < \log n(a)$

$$\log n$$

$$\text{SPL} = \overline{M(b)} + \text{SPL}(b)$$

d) $\log n \geq \log n(a)$

$$\log n$$

$$\text{SPL} = \overline{M(c)} + \text{SPL}(c)$$

Case 2: Figure A1-3 b): $400 \leq f \leq 6300$ Hz

$$n = \text{antilog } M(c) [\text{SPL} - \text{SPL}(c)]$$

$$\text{SPL} = \frac{\log n}{M(c)} + \text{SPL}(c)$$

$$M(c)$$

Note 4.- Table A1-4 lists the values of the important constants necessary to calculate sound pressure level



as a function of perceived noisiness

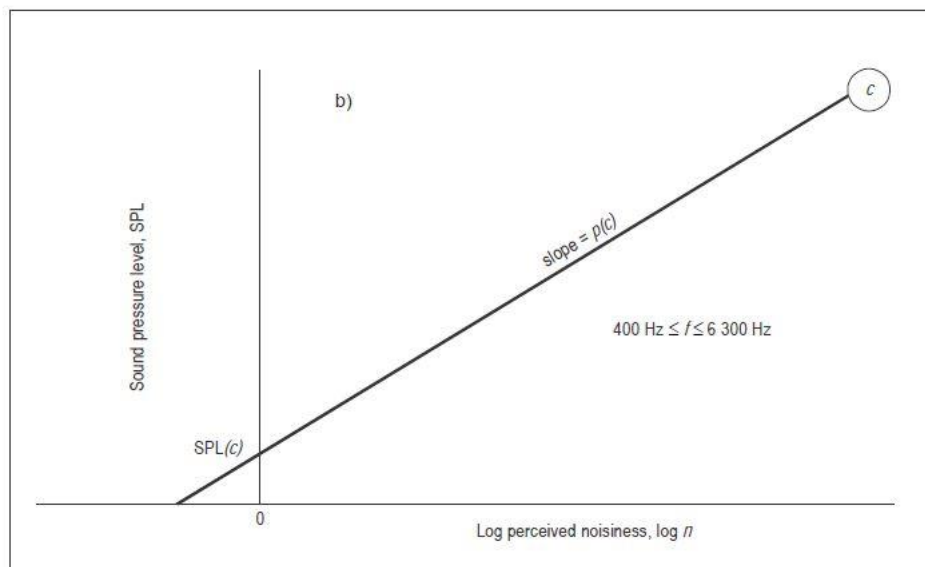
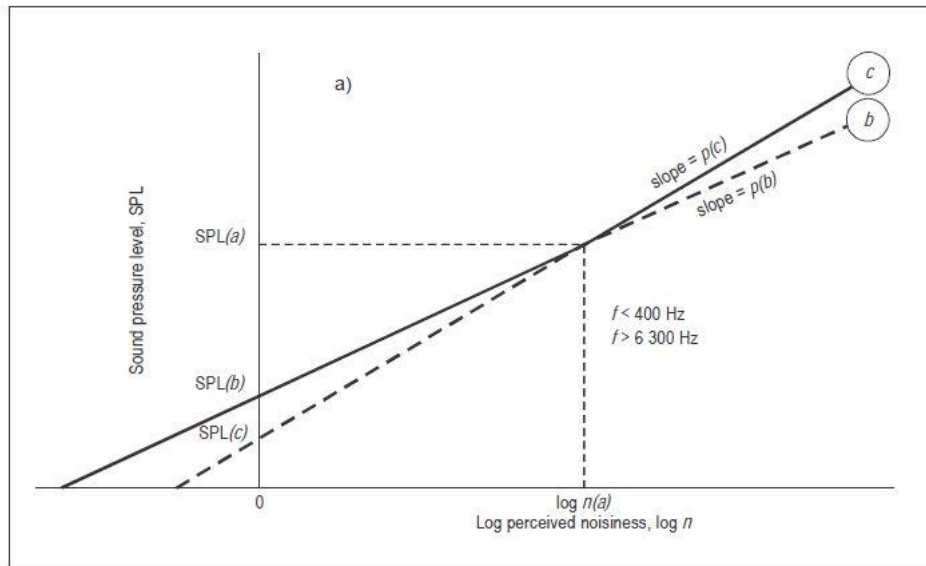


Figure A1-3. Sound pressure level as a function of perceived noisiness

Table A1-4. Constants for mathematically formulated noy values

Band (i)	f Hz	M(b)	SPL(b) dB	SPL(a) dB	M(c)	SPL(c) dB	
1	50	0.043478	64	91.0	0.030103	52	
2	63	0.040570	60	85.9	↑	51	
3	80	0.036831	56	87.3		49	
4	100	"	53	79.9		47	
5	125	0.035336	51	79.8		46	
6	160	0.033333	48	76.0		45	
7	200	"	46	74.0		43	
8	250	0.032051	44	74.9		42	
9	315	0.030675	42	94.6		41	
10	400	—	—	—		↓	40
11	500	—	—	—	40		
12	630	—	—	—	40		
13	800	—	—	—	40		
14	1 000	—	—	—	40		
15	1 250	—	—	—	0.030103		38
16	1 600	—	—	—	0.029960		34
17	2 000	—	—	—	↑		32
18	2 500	—	—	—			30
19	3 150	—	—	—			29
20	4 000	—	—	—		29	
21	5 000	—	—	—		30	
22	6 300	—	—	—		31	
23	8 000	0.042285	37	44.3		34	
24	10 000	0.042285	41	50.7		0.029960	37

NOT APPLICABLE

8. SOUND ATTENUATION IN AIR

- 8.1 The atmospheric attenuation of sound should be determined in accordance with the procedure presented below.
- 8.2 The relationship between sound attenuation, frequency, temperature and humidity is expressed by the following equations:

$$\alpha(i) = 10^{[2.05 \log(f_o/1000) + 1.1394 \times 10^{-3}\theta - 1.916984]} + \eta(\delta) \times 10^{[\log(f_o) + 8.42994 \times 10^{-3}\theta - 2.755624]}$$

$$\delta = \sqrt{\frac{1010}{f_o}} 10^{(\log H - 1.328924 + 3.179768 \times 10^{-2}\theta)} \times 10^{(-2.173716 \times 10^{-4}\theta^2 + 1.7496 \times 10^{-6}\theta^3)}$$

where:

$\eta(\delta)$ is given by Table A1-5 and f_o by Table A1-6;

$\alpha(i)$ being the attenuation coefficient in dB/100 m;

θ being the temperature in °C; and

H being the relative humidity.

- 8.3 The equations given in 8.2 are convenient for calculation by means of a computer. For use in other cases, numerical values determined from the equations are given in Tables A1-7 to A1-16.

Table A1-5

δ	η	δ	η
0.00	0.000	2.30	0.495
0.25	0.315	2.50	0.450
0.50	0.700	2.80	0.400
0.60	0.840	3.00	0.370
0.70	0.930	3.30	0.330
0.80	0.975	3.60	0.300
0.90	0.996	4.15	0.260
1.00	1.000	4.45	0.245
1.10	0.970	4.80	0.230
1.20	0.900	5.25	0.220
1.30	0.840	5.70	0.210
1.50	0.750	6.05	0.205
1.70	0.670	6.50	0.200

2.00 0.570 7.00 0.200
10.00 0.200

Table A1-6

<i>one-third octave center frequency</i>	<i>f_o</i> (Hz)	<i>one-third octave center frequency</i>	<i>f_o</i> (Hz)
50	50	800	800
63	63	1 000	1000
80	80	1 250	1250
100	100	1 600	1600
125	125	2 000	2000
160	160	2 500	2500
200	200	3 150	3150
250	250	4 000	4000
315	315	5 000	4500
400	400	6 300	5600
500	500	8 000	7100
630	630	10 000	9 000



Table A1-7. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 10%										
	Temperature, °C										
Hz	-10	-5	0	5	10	15	20	25	30	35	40
50	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
125	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.2	0.2	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.3	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.2
250	0.2	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2	0.2
315	0.2	0.4	0.5	0.6	0.5	0.4	0.3	0.2	0.2	0.2	0.2
400	0.3	0.5	0.7	0.8	0.6	0.5	0.4	0.3	0.3	0.3	0.3
500	0.3	0.5	0.8	1.0	0.9	0.7	0.6	0.5	0.4	0.4	0.4
630	0.3	0.6	0.9	1.2	1.2	1.0	0.9	0.7	0.6	0.5	0.5
800	0.4	0.6	1.0	1.5	1.7	1.5	1.2	1.0	0.8	0.7	0.6
1 000	0.4	0.7	1.2	1.8	2.1	2.0	1.7	1.4	1.2	1.0	0.9
1 250	0.4	0.8	1.3	2.1	2.6	2.8	2.4	2.0	1.7	1.4	1.2
1 600	0.5	0.9	1.4	2.3	3.3	3.8	3.4	2.9	2.4	2.0	1.7
2 000	0.6	1.0	1.6	2.6	3.9	4.7	4.7	4.1	3.4	2.8	2.3
2 500	0.7	1.1	1.8	2.9	4.5	5.8	6.4	5.6	4.8	4.0	3.3
3 150	0.8	1.2	2.0	3.2	5.1	7.1	8.3	7.7	6.8	5.7	4.8
4 000	0.9	1.4	2.3	3.6	5.7	8.5	10.5	11.0	9.6	8.3	6.9
5 000	1.0	1.6	2.4	3.8	6.1	9.2	11.7	12.8	11.3	9.9	8.3
6 300	1.3	1.9	2.8	4.3	6.8	10.4	14.2	16.4	15.5	13.7	11.7
8 000	1.6	2.3	3.4	5.0	7.7	11.8	17.0	20.8	22.0	19.4	16.8
10 000	2.1	2.9	4.1	6.0	8.9	13.4	19.9	25.9	29.5	27.2	24.1
12 500	2.9	3.7	5.0	7.1	10.3	15.3	22.7	31.2	36.9	37.6	33.4



		Table A1-8.		Sound attenuation coefficient in dB/100 m									
<i>Band center frequency</i>				<i>Relative humidity = 20%</i>									
				<i>Temperature, °C</i>									
Hz	-10	-5	0	5	10	15	20	25	30	35	40		
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
63	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
80	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1		
100	0.1	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1		
125	0.2	0.1	0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1		
160	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
200	0.3	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2		
250	0.4	0.3	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2		
315	0.4	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2		
400	0.5	0.6	0.5	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.3		
500	0.6	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.3	0.3	0.4		
630	0.7	1.0	1.0	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5		
800	0.8	1.2	1.4	1.2	0.9	0.7	0.6	0.5	0.5	0.6	0.6		
1 000	0.9	1.4	1.8	1.6	1.3	1.0	0.8	0.7	0.7	0.7	0.8		
1 250	0.9	1.6	2.2	2.2	1.8	1.5	1.2	1.0	0.9	0.9	1.0		
1 600	1.1	1.9	2.7	3.1	2.6	2.1	1.7	1.4	1.2	1.2	1.3		
2 000	1.2	2.0	3.2	3.9	3.6	3.0	2.5	2.0	1.7	1.5	1.6		
2 500	1.3	2.3	3.7	4.9	5.0	4.2	3.5	2.8	2.3	2.0	2.0		
3 150	1.5	2.5	4.2	6.0	6.8	5.8	4.9	4.0	3.3	2.8	2.7		
4 000	1.7	2.9	4.8	7.2	8.7	8.2	7.1	5.9	4.9	4.0	3.6		
5 000	1.9	3.1	5.1	7.9	9.8	9.7	8.4	7.0	5.9	4.8	4.2		
6 300	2.2	3.5	5.7	9.0	12.0	13.3	11.5	9.9	8.2	6.8	5.8		
8 000	2.7	4.1	6.5	10.4	14.8	17.4	16.2	14.1	12.0	10.0	8.3		
10 000	3.3	4.9	7.5	11.8	17.7	22.0	23.1	20.1	17.2	14.5	12.1		
12 500	4.1	5.9	8.8	13.4	20.5	27.1	30.6	27.5	24.2	20.6	17.4		



Table A1-10. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 40%										
	Temperature, °C										
Hz	-10	-5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.1	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.3	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.5	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.6	0.5	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.9	0.7	0.5	0.4	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	1.2	1.0	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1 000	1.4	1.4	1.1	0.8	0.6	0.5	0.5	0.6	0.6	0.7	0.8
1 250	1.8	1.9	1.5	1.2	0.9	0.7	0.7	0.7	0.8	0.9	1.0
1 600	2.1	2.6	2.1	1.7	1.3	1.0	0.9	0.9	1.0	1.1	1.3
2 000	2.5	3.2	2.9	2.4	1.9	1.5	1.2	1.2	1.3	1.4	1.6
2 500	2.8	4.0	4.1	3.3	2.6	2.1	1.7	1.6	1.7	1.8	2.0
3 150	3.2	4.9	5.6	4.7	3.8	3.0	2.4	2.1	2.1	2.3	2.5
4 000	3.6	5.9	7.2	6.5	5.4	4.3	3.5	3.0	2.8	3.0	3.3
5 000	3.8	6.3	8.1	7.7	6.5	5.2	4.2	3.5	3.3	3.4	3.7
6 300	4.3	7.2	10.0	10.7	9.0	7.3	6.0	4.9	4.4	4.3	4.7
8 000	5.0	8.3	12.3	14.4	12.6	10.6	8.7	7.1	6.1	5.8	6.2
10 000	5.8	9.5	14.8	18.4	17.8	15.2	12.7	10.5	8.8	8.1	8.1
12 500	6.9	10.9	17.2	22.9	24.7	21.2	17.8	14.9	12.4	10.9	10.6



Table A1-11. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 50%											
	Temperature, °C											
Hz	-10	-5	0	5	10	15	20	25	30	35	40	
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	
125	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	
250	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	
315	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	
400	0.4	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	
500	0.5	0.4	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	
630	0.7	0.6	0.4	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5	
800	1.0	0.8	0.6	0.5	0.4	0.4	0.4	0.5	0.5	0.6	0.6	
1 000	1.4	1.1	0.9	0.6	0.5	0.5	0.5	0.6	0.6	0.7	0.8	
1 250	1.8	1.6	1.2	0.9	0.7	0.6	0.7	0.7	0.8	0.9	1.0	
1 600	2.3	2.2	1.8	1.3	1.0	0.9	0.9	0.9	1.0	1.1	1.3	
2 000	2.8	3.1	2.4	1.9	1.5	1.2	1.1	1.2	1.3	1.4	1.6	
2 500	3.4	4.0	3.4	2.7	2.1	1.6	1.5	1.5	1.7	1.8	2.0	
3 150	4.0	5.1	4.7	3.8	3.0	2.3	2.0	1.9	2.1	2.3	2.5	
4 000	4.6	6.4	6.7	5.5	4.4	3.4	2.8	2.6	2.7	3.0	3.3	
5 000	4.9	7.2	7.9	6.5	5.2	4.2	3.4	3.1	3.1	3.4	3.7	
6 300	5.4	8.6	10.2	8.9	7.3	5.9	4.7	4.1	4.0	4.3	4.7	
8 000	6.2	10.2	13.1	12.5	10.5	8.6	6.9	5.8	5.4	5.7	6.2	
10 000	7.2	11.9	16.4	17.8	15.0	12.4	10.2	8.4	7.5	7.4	8.1	
12 500	8.4	13.6	20.1	23.4	20.6	17.5	14.4	11.9	10.4	9.9	10.5	



Table A1-12. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 60%										
	Temperature, °C										
Hz	-10	-5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.2	0.2	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.6	0.5	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.9	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1 000	1.2	1.0	0.7	0.5	0.5	0.5	0.5	0.6	0.6	0.7	0.8
1 250	1.7	1.3	1.0	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1 600	2.3	1.9	1.5	1.1	0.9	0.8	0.9	0.9	1.0	1.1	1.3
2 000	2.9	2.6	2.1	1.6	1.2	1.1	1.1	1.2	1.3	1.4	1.6
2 500	3.6	3.6	2.9	2.2	1.7	1.4	1.4	1.5	1.7	1.8	2.0
3 150	4.4	5.0	4.1	3.2	2.5	2.0	1.8	1.9	2.1	2.3	2.5
4 000	5.3	6.6	5.7	4.6	3.6	2.8	2.5	2.5	2.7	3.0	3.3
5 000	5.8	7.4	6.8	5.5	4.3	3.4	2.9	2.9	3.1	3.4	3.7
6 300	6.6	9.2	9.3	7.7	6.1	4.9	4.0	3.8	4.0	4.3	4.7
8 000	7.6	11.4	13.0	10.9	8.9	7.2	5.8	5.2	5.2	5.7	6.2
10 000	8.7	13.8	16.9	15.3	12.8	10.4	8.5	7.3	7.0	7.4	8.1
12 500	10.0	16.1	21.1	21.2	18.0	14.8	12.2	10.2	9.5	9.6	10.5



Table A1-13. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 70%										
	Temperature, °C										
Hz	-10	-5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2	0.2	0.2
315	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.4	0.3	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.4
630	0.6	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.8	0.6	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.6	0.6
1 000	1.1	0.8	0.6	0.5	0.4	0.5	0.5	0.6	0.7	0.7	0.8
1 250	1.5	1.1	0.9	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1 600	2.1	1.7	1.2	0.9	0.8	0.8	0.9	1.0	1.0	1.1	1.3
2 000	2.9	2.3	1.8	1.3	1.0	1.0	1.1	1.2	1.3	1.4	1.6
2 500	3.7	3.2	2.5	1.9	1.5	1.3	1.4	1.5	1.7	1.8	2.0
3 150	4.6	4.4	3.5	2.7	2.1	1.8	1.8	1.9	2.1	2.3	2.5
4 000	5.7	6.3	5.1	4.0	3.1	2.5	2.3	2.5	2.7	3.0	3.3
5 000	6.3	7.3	6.0	4.7	3.7	3.0	2.7	2.9	3.1	3.4	3.7
6 300	7.5	9.3	8.2	6.6	5.2	4.2	3.6	3.6	4.0	4.3	4.7
8 000	8.8	11.8	11.6	9.5	7.6	6.1	5.1	4.9	5.2	5.7	6.2
10 000	10.2	14.8	16.4	13.7	11.1	9.0	7.4	6.8	6.8	7.4	8.1
12 500	11.6	18.0	21.4	18.8	15.7	12.8	10.5	9.2	9.0	9.6	10.5



Band center frequency	Relative humidity = 80%										
	Temperature, °C										
Hz	-10	-5	0	5	10	15	20	25	30	35	40
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
315	0.2	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2
400	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4
630	0.5	0.3	0.3	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5
800	0.7	0.5	0.4	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6
1 000	1.0	0.7	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8
1 250	1.3	1.0	0.7	0.6	0.6	0.6	0.7	0.7	0.8	0.9	1.0
1 600	1.9	1.5	1.1	0.8	0.7	0.8	0.9	0.9	1.0	1.1	1.3
2 000	2.6	2.0	1.5	1.1	1.0	1.0	1.1	1.2	1.3	1.4	1.6
2 500	3.6	2.9	2.2	1.6	1.3	1.3	1.4	1.5	1.7	1.8	2.0
3 150	4.7	4.0	3.1	2.4	1.9	1.7	1.8	1.9	2.1	2.3	2.5
4 000	5.9	5.6	4.5	3.4	2.7	2.3	2.3	2.5	2.7	3.0	3.3
5 000	6.6	6.6	5.3	4.1	3.2	2.7	2.6	2.8	3.1	3.4	3.7
6 300	8.1	9.1	7.4	5.9	4.6	3.7	3.4	3.6	4.0	4.3	4.7
8 000	9.8	12.0	10.4	8.4	6.7	5.4	4.8	4.8	5.2	5.7	6.2
10 000	11.5	15.3	14.8	12.2	9.8	7.8	6.7	6.4	6.8	7.4	8.1
12 500	13.3	18.9	20.5	17.0	13.9	11.3	9.4	8.7	8.9	9.6	10.5



Table A1-15. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 90%											
	Temperature, °C											
Hz	-10	-5	0	5	10	15	20	25	30	35	40	
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	
400	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	
1 000	0.9	0.6	0.5	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	
1 250	1.2	0.9	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	
1 600	1.7	1.3	0.9	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	
2 000	2.4	1.8	1.3	1.0	0.9	1.0	1.1	1.2	1.3	1.4	1.6	
2 500	3.3	2.6	1.9	1.4	1.2	1.3	1.4	1.5	1.7	1.8	2.0	
3 150	4.6	3.6	2.8	2.1	1.7	1.6	1.8	1.9	2.1	2.3	2.5	
4 000	6.0	5.1	4.0	3.0	2.4	2.2	2.3	2.5	2.7	3.0	3.3	
5 000	6.7	6.0	4.8	3.7	2.9	2.6	2.6	2.8	3.1	3.4	3.7	
6 300	8.3	8.3	6.7	5.2	4.0	3.4	3.3	3.6	4.0	4.3	4.7	
8 000	10.4	11.7	9.5	7.6	6.0	4.9	4.5	4.8	5.2	5.7	6.2	
10 000	12.6	15.4	13.5	11.0	8.8	7.1	6.3	6.3	6.8	7.4	8.1	
12 500	14.8	19.4	18.6	15.4	12.4	10.1	8.7	8.3	8.9	9.6	10.5	



Table A1-16. Sound attenuation coefficient in dB/100 m

Band center frequency	Relative humidity = 100%											
	Temperature, °C											
Hz	-10	-5	0	5	10	15	20	25	30	35	40	
50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
80	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	
100	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	
125	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
160	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
200	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	
250	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	
315	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	
400	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	
500	0.3	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.4	
630	0.4	0.3	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.5	
800	0.6	0.4	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.6	0.6	
1 000	0.8	0.6	0.4	0.4	0.4	0.5	0.5	0.6	0.6	0.7	0.8	
1 250	1.1	0.8	0.6	0.5	0.6	0.6	0.7	0.7	0.8	0.9	1.0	
1 600	1.6	1.2	0.8	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	
2 000	2.2	1.6	1.2	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	
2 500	3.0	2.3	1.7	1.3	1.2	1.3	1.4	1.5	1.7	1.8	2.0	
3 150	4.2	3.3	2.5	1.9	1.6	1.6	1.8	1.9	2.1	2.3	2.5	
4 000	5.9	4.7	3.6	2.7	2.2	2.1	2.3	2.5	2.7	3.0	3.3	
5 000	6.8	5.6	4.3	3.3	2.6	2.4	2.6	2.8	3.1	3.4	3.7	
6 300	8.5	7.6	6.0	4.7	3.7	3.3	3.3	3.6	4.0	4.3	4.7	
8 000	10.7	10.8	8.7	6.8	5.3	4.5	4.4	4.8	5.2	5.7	6.2	
10 000	13.3	15.1	12.5	10.0	7.9	6.5	6.0	6.3	6.8	7.4	8.1	
12 500	16.0	19.5	17.2	14.0	11.3	9.2	8.2	8.2	8.9	9.6	10.5	

9. DETAILED CORRECTION PROCEDURES

9.1 Introduction

9.1.1 When the noise certification test conditions are not identical to the noise certification reference conditions, appropriate corrections should be made to the EPNL calculated from the measured data by the methods of this section.

Note1.- Differences between reference and test conditions which lead to corrections can result from the following:

- a) *atmospheric absorption of sound under test conditions different from reference;*
- b) *test flight path at altitude different from reference; and*
- c) *test mass different from maximum.*

Note 2- Negative correction can arise if the atmospheric absorption of sound under test conditions is less than reference and also if the test flight path is at a lower altitude than reference.

The take-off test flight path can occur at a higher altitude than reference if the meteorological conditions permit superior aeroplane performance (“cold day” effect). Conversely, the “hot day” effect can cause the take-off test flight path to occur at a lower altitude than reference. The approach test flight path can occur at either higher or lower altitudes than reference irrespective of the meteorological conditions.

9.1.2 The measured noise values should be properly corrected to the reference conditions, either by the correction procedures presented as follows or by an integrated programme which should be approved as being equivalent.


9.1.2.1 Correction procedures should consist of one or more values added algebraically to the EPNL calculated as if the tests were conducted completely under the noise certification reference conditions.

9.1.2.2 The flight profiles should be determined for both take-off and approach, and for both reference and test conditions. The test procedures should require noise and flight path recordings with a synchronized time signal from which the test profile can be delineated, including the aeroplane position for which PNLTM is observed at the noise measuring station. For take-off, a flight profile corrected to reference conditions should be derived from data approved by the certificating authority.

Note.- For approach, the reference profile is defined by the reference conditions in 5.3.

9.1.2.3 The differing noise path lengths from the aeroplane to the noise measuring station corresponding to PNLTM should be determined for the test and reference conditions. The SPL values in the spectrum of PNLTM should then be corrected for the effects of:

- a) change in atmospheric sound absorption;

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- b) atmospheric sound absorption on the change in noise path length; and
- c) inverse square law on the change in noise path length.

9.1.2.4 The corrected values of SPL should then be converted to PNLT from which PNLTM is subtracted.

Note.- *The difference represents the correction to be added algebraically to the EPNL calculated from the measured data.*

9.1.3 The minimum distances from both the test and reference profiles to the noise measuring station should be calculated and used to determine a noise duration correction due to the change in the altitude of aeroplane flyover. The duration correction should be added algebraically to the EPNL calculated from the measured data.

9.1.4 From manufacturer’s data (approved by the certificating authority) in the form of curves, tables or in some other manner giving the variation of EPNL with take-off mass and also for landing mass, corrections should be determined to be added to the EPNL calculated from the measured data to account for noise level changes due to differences between maximum take-off mass and landing mass and test aeroplane mass.

9.1.5 From manufacturer’s data (approved by the certificating authority) in the form of curves, tables or in some manner giving the variation of EPNL with approach angle, corrections should be determined to be added algebraically to the EPNL calculated from measured data to account for noise level changes due to differences between the reference and the test approach angles.

9.2 Take-off profiles

Note.—


- a) *Figure A1-4 illustrates a typical take-off profile. The aeroplane begins the take-off roll at point A, lifts off at point B, and initiates the first constant climb at point C at an angle β . The noise abatement thrust cutback is started at point D and completed at point E where the second constant climb is defined by the angle γ (usually expressed in terms of the gradient in per cent).*
- b) *The end of the noise certification take-off flight path is represented by aeroplane position F whose vertical projection on the flight track (extended center line of the runway) is point M. The position of the aeroplane is recorded for a distance AM of at least 11 km (6 NM).*
- c) *Position K is the take-off noise measuring station whose distance AK is the specified take-off measurement distance. Position L is the sideline noise measuring station located on a line parallel to and the specified distance from the runway center line where the noise level during take-off is greatest.*

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- d) *The thrust settings after thrust reduction, if used, under the test conditions are such as would produce at least the minimum certification gradient for the reference conditions of atmosphere and mass.*
- e) *The take-off profile is associated with the following five parameters: AB, the length of take-off roll; β , the first constant climb angle; γ , the second constant climb angle; and δ and ϵ , the thrust cutback angles. These five parameters are functions of the aeroplane performance, mass and atmospheric conditions (ambient air temperature, pressure, and wind velocity). If the test atmospheric conditions are not equal to the reference atmospheric conditions, the corresponding test and reference profile parameters will be different as shown in Figure A1-5. The profile parameter changes (identified as AB, β , $\Delta\gamma$, $\Delta\delta$ and $\Delta\epsilon$) can be derived from the manufacturer’s data (approved by the certificating authority) and are used to define the flight profile corrected to the atmospheric reference conditions, the aeroplane mass being unchanged from that of the test. The relationships between the measured and corrected take-off flight profiles can then be used to determine the corrections which are applied to the EPNL calculated from the measured data.*
- f) *Figure A1-6 illustrates portions of the measured and corrected take-off flight paths including the significant geometrical relationships influencing sound propagation. EF represents the second constant measured flight path with climb angle γ , and E_c F_c represents the second constant corrected flight path at different altitude and with different climb angle $\gamma + \Delta\gamma$.*
- g) *Position Q represents the aeroplane location on the measured take-off flight path for which PNLT_M is observed at the noise measuring station K, and Q_c is the corresponding position on the corrected flight path. The measured and corrected noise propagation paths are KQ and KQ_c , respectively, which are assumed to form the same angle θ with their flight paths. This assumption of constant angle θ is one which may not be valid in all cases. Future refinement should be sought. However, for the present application of this test procedure, any differences are considered small.*
- h) *Position R represents the point on the measured take-off flight path nearest the noise measuring station K, and R_c is the corresponding position on the corrected flight path. The minimum distance to the measured and corrected flight paths are indicated by the lines KR and KR_c , respectively, which are normal to their flight paths.*

If two peak values of PNLT are observed during flyover which differ by less than 2 TPNdB that noise level which, when corrected to reference conditions, gives the greater value should be used in the computation for EPNL at the reference conditions. In that case the point corresponding to the second peak should be obtained on the corrected flight path by applying manufacturer’s approved data.

9.3 Approach profiles

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Note.-

- a) *Figure A1-7 illustrates a typical approach profile. The beginning of the noise certification approach profile is represented by aeroplane position G whose vertical projection on the flight track (extended center line of the runway) is point P. The position of the aeroplane is recorded for a distance PO from the runway threshold O of at least 7.4 km (4 NM).*
- b) *The aeroplane approaches at an angle η , passes vertically over the noise measuring station N at a height of NH, begins the level-off at position I, and touches down at position J.*
- c) *The approach profile is defined by the approach angle η and the height NH which are functions of the aeroplane operating conditions controlled by the pilot. If the measured approach profile parameters are different from the corresponding reference approach parameters (Figure A1-8), corrections are applied to the EPNL calculated from the measured data.*
- d) *Figure A1-9 illustrates portions of the measured and reference approach flight paths including the significant geometrical relationships influencing sound propagation. GI represents the measured approach path with approach angle η , and $G_r I_r$ represents the reference approach flight path at reference altitude and the reference approach angle η_r .*
- e) *Position S represents the aeroplane location on the measured approach flight path for which PNLTM is observed at the noise measuring station N, and S_r is the corresponding position on the reference approach flight path. The measured and corrected noise propagation paths are NS and NS_r respectively, which form the same angle λ with their flight paths.*
- f) *Position T represents the point on the measured approach flight path nearest the noise measuring station N, and T_r is the corresponding point on the reference approach flight path. The minimum distances to the measured and reference flight paths are indicated by the lines NT and NT_r , respectively, which are normal to their flight paths.*

9.4 PNLT corrections

9.4.1 Whenever the ambient atmospheric conditions of temperature and relative humidity differ from the reference conditions and/or whenever the measured take-off and approach flight paths differ from the reference flight paths respectively, corrections to the EPNL values calculated from the measured data should be applied. These

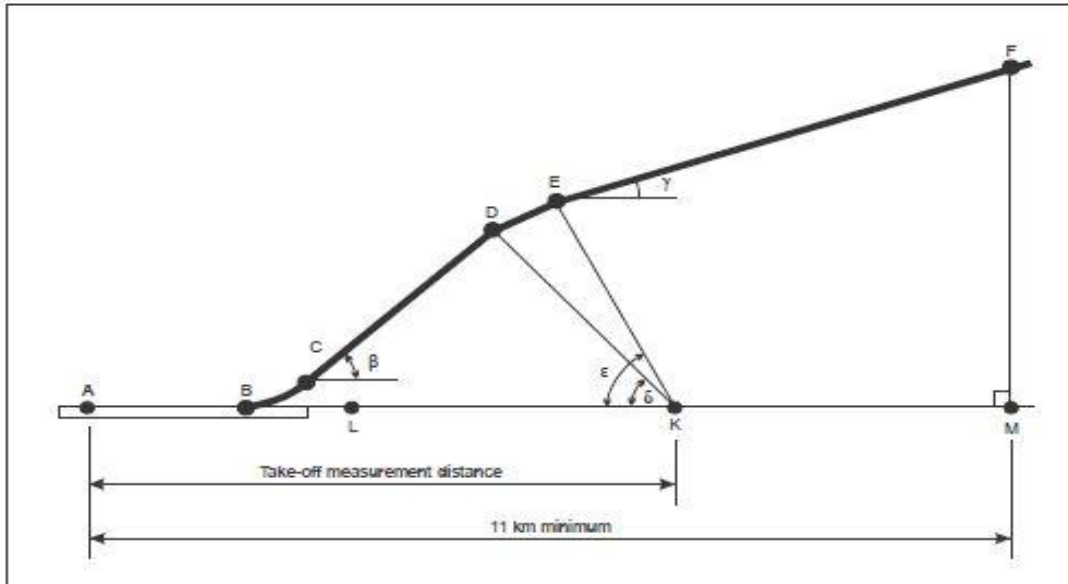


Figure A1-4. Measured take-off profile

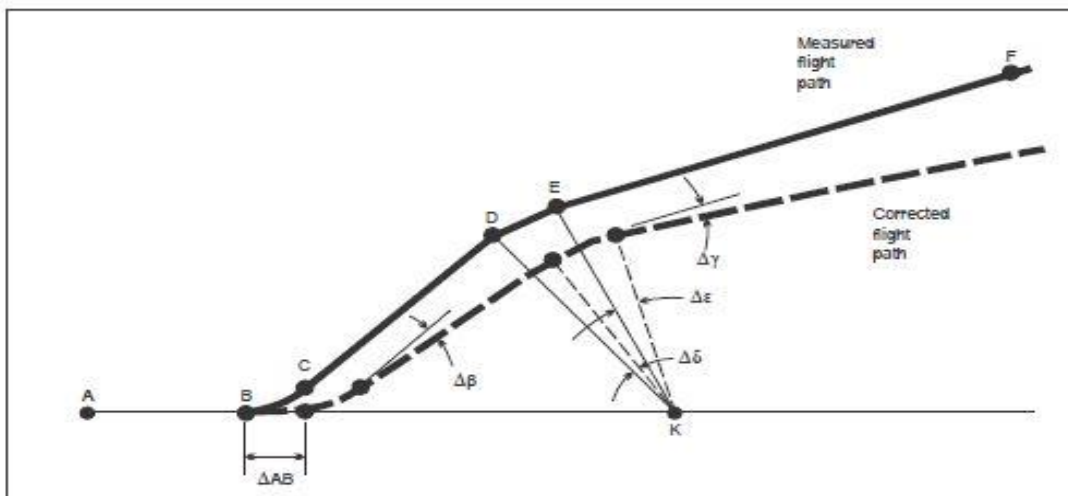


Figure A1-5. Comparison of measured and corrected take-off profiles

corrections should be calculated as described below:

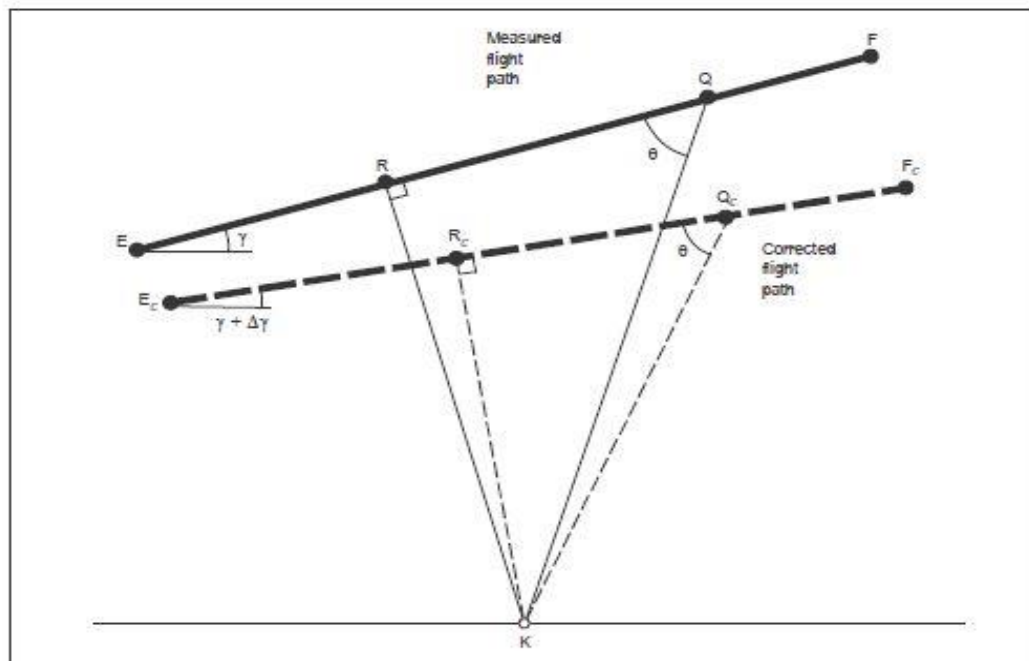


Figure A1-6. Take-off profile characteristics influencing sound level

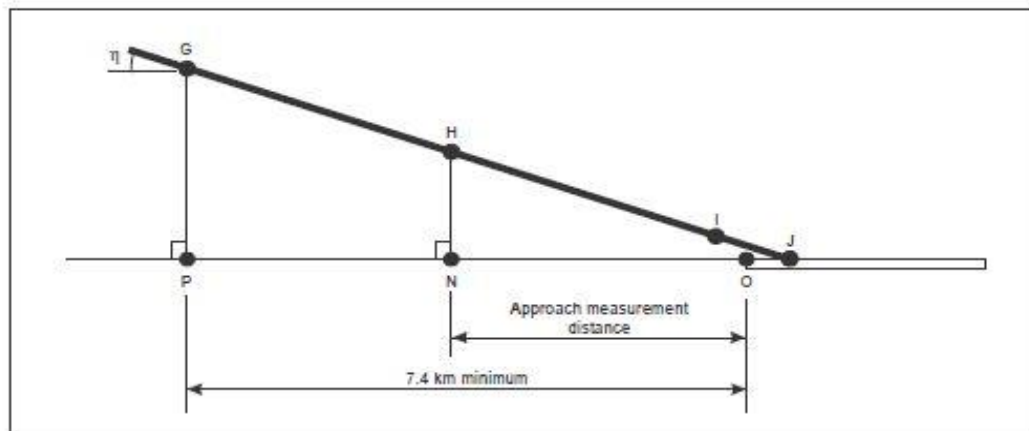


Figure A1-7. Measured approach profile

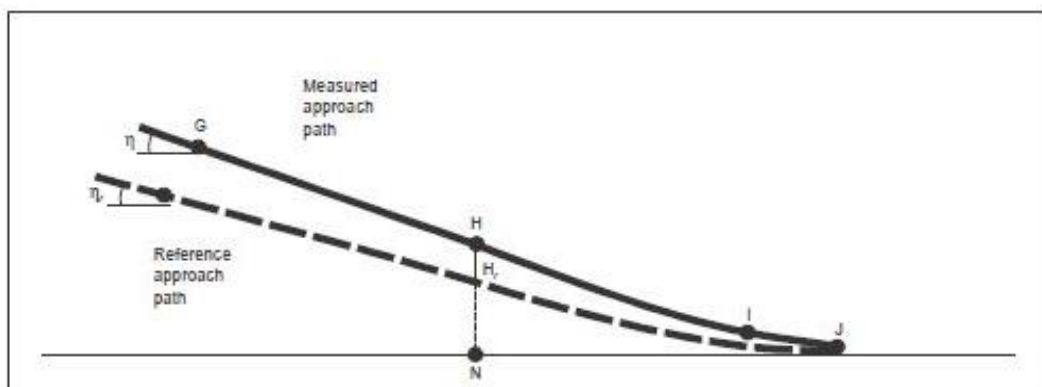


Figure A1-8. Comparison of measured and corrected approach profile

9.4.1.1 *Take-off*

9.4.1.1.1 Referring to a typical take-off flight path shown in Figure A1-6, the spectrum of PNLTM observed at station K, for the aeroplane at position Q, should be decomposed into its individual SPL(*i*) values. A set of corrected values should be computed as follows:

$$SPL(i)_c = SPL(i) + 0.01[\alpha(i) - \alpha(i)_o] KQ + 0.01 \alpha(i)_o (KQ - KQ_c) + 20 \log (KQ/KQ_c)$$

- the term $0.01 [\alpha(i) - \alpha(i)_o] KQ$ accounts for the effects of the change in atmospheric sound absorption where $\alpha(i)$ and $\alpha(i)_o$ are the sound absorption coefficients for the test and reference conditions respectively for the *i*-th one-third octave band and KQ is the measured take-off noise path;
- the term $0.01 \alpha(i)_o (KQ - KQ_c)$ accounts for the effect of atmospheric sound absorption on the change in the noise path length, where KQ_c is the corrected take-off noise path; and
- the term $20 \log (KQ/KQ_c)$ accounts for the effects of the inverse square law on the change in the noise path length.

9.4.1.1.2 The corrected values of SPL(*i*)_c should then be converted to PNLT and a correction term calculated as follows:

$$\Delta_1 = PNLT - PNLTM$$

which represents the correction to be added algebraically to the EPNL calculated from the measured data.

9.4.1.2 *Approach*

The same procedure should be used for the approach flight path except that the values for SPL(*i*)_c relate to the approach noise paths shown in Figure A1-9 as follows:

$$SPL(i)_c = SPL(i) + 0.01 [\alpha(i) - \alpha(i)_o] NS + 0.01 \alpha(i)_o (NS - NS_r) + 20 \log (NS/NS_r)$$

where NS and NS_r are the measured and reference approach noise paths, respectively. The remainder of the procedure should be the same as for the take-off flight path.

9.4.1.3 *Lateral*

The same procedure should be used for the lateral flight path except that the values for SPL(*i*)_c relate only to the measured lateral noise path as follows:

$$SPL(i)_c = SPL(i) + 0.01 [\alpha(i) - \alpha(i)_o] LX$$

where LX should be the measured lateral noise path from station L (Figure A1-4) to position X of the aeroplane for which PNLTM is observed at station L. Only the correction term accounting for the effects of change in atmospheric sound absorption should be considered. The difference between the measured and corrected noise path lengths should be assumed negligible for the lateral flight path. The remainder of the procedure should be the same as for the take-off flight path.

9.5 Duration correction

9.5.1 Whenever the measured take-off and approach flight paths differ from the corrected and reference flight paths, respectively, duration corrections to the EPNL values calculated from the measured data should be applied. These corrections should be calculated as described below:

9.5.1.1 Take-off

Referring to the take-off flight path shown in Figure A1-6, a correction term should be calculated as follows:

$$\Delta_2 = -7.5 \log (KR/KR_c)$$

which represents the corrections to be added algebraically to the EPNL calculated from the measured data. The lengths KR and KR_c should be the measured and corrected take-off minimum distances, respectively, from the noise measuring station K to the measured and corrected flight paths. The negative sign should indicate that, for the particular case of a duration correction, the EPNL calculated from the measured data should be reduced if the measured flight path is at a greater altitude than the corrected flight path.

9.5.1.2 Approach

The same procedure should be used for the approach flight path except that the correction relates to the approach minimum distances shown in Figure A1-9 as follows:

$$\Delta_2 = -7.5 \log (NT/NT_r)$$

where NT is the measured approach minimum distance from the noise measuring station N to the measured flight path.

9.5.1.3 Lateral

No duration correction should be computed for the lateral flight path because the differences between the measured and corrected flight paths are assumed negligible.



9.6 Mass correction

Whenever the aeroplane mass, during either the noise certification take-off or approach test, is different from the corresponding maximum take-off or landing mass, a correction should be applied to the EPNL value calculated from the measured data. The corrections should be determined from the manufacturer's data (approved by the certifying authority) in the form of tables or curves such as schematically indicated in Figures A1-10 and A1-11. The manufacturer's data should be applicable to the noise certification reference atmospheric conditions.

9.7 Approach angle correction

Whenever the aeroplane approach angle during the noise certification approach test is different from the reference approach angle, a correction should be applied to the EPNL value calculated from the measured data. The corrections should be determined from the manufacturer's data (approved by the certifying authority) in the form of tables or curves such as schematically indicated in Figure A1-12. The manufacturer's data should be applicable to the noise certification reference atmospheric conditions and to the test landing mass

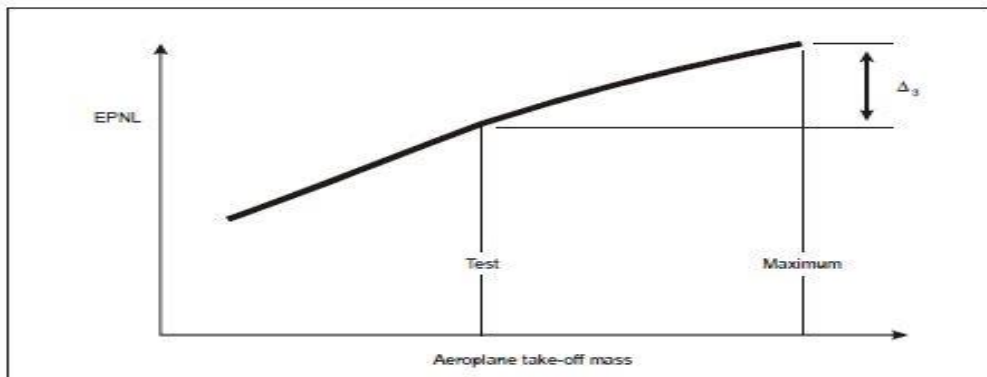


Figure A1-10. Take-off mass correction for EPNL

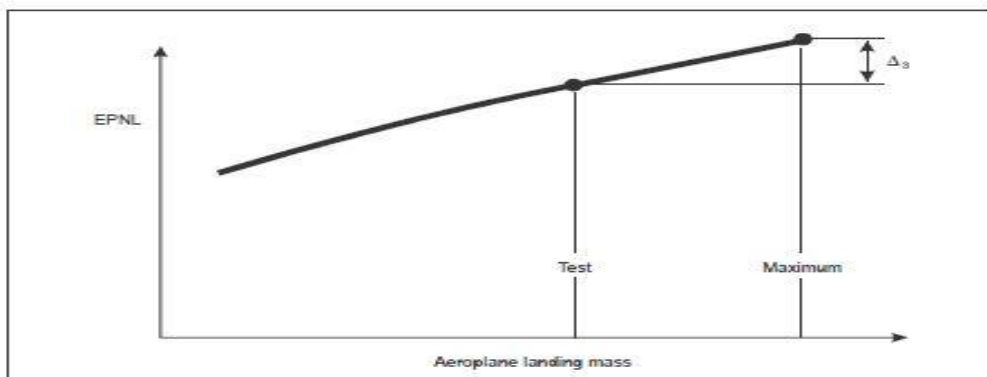


Figure A1-11. Approach mass correction for EPNL

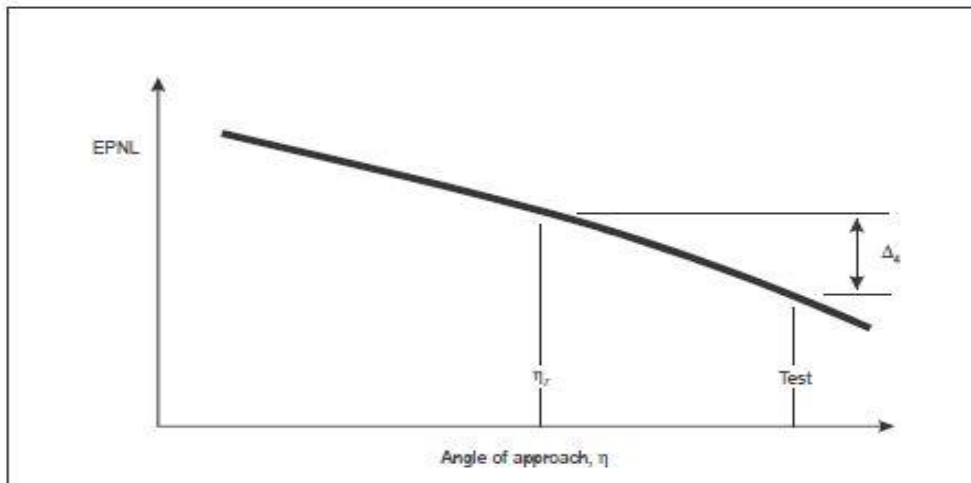


Figure A1-12. Approach angle correction for EPNL

APPENDIX 2. EVALUATION METHOD FOR NOISE CERTIFICATION

1. SUBSONIC JET AEROPLANES — Application for

Type Certificate submitted on or after 6 October 1977

2. PROPELLER-DRIVEN AEROPLANES OVER 8 618 kg —

Application for Type Certificate submitted on or after 1 January 1985

3. HELICOPTERS

4. TILT-ROTORS

Note. See Part II, Chapters 3, 4, 8, 13 and 14.

1. INTRODUCTION

Note 1—This noise evaluation method includes:

- a) noise certification test and measurement conditions;
- b) measurement of aeroplane and helicopter noise received on the ground;
- c) calculation of effective perceived noise level from measured noise data; and
- d) reporting of data to the certifying authority and correcting measured data.

Note 2- The instructions and procedures given in the method are clearly delineated to ensure uniformity during compliance tests, and to permit comparison between tests of various types of aircraft conducted in various geographical locations.


Note 3- A complete list of symbols and units, the mathematical formulation of perceived noisiness, a procedure for determining atmospheric attenuation of sound, and detailed procedures for correcting noise levels from non-reference to reference conditions are included in Sections 4, 7 and 8 of this appendix.

2. NOISE CERTIFICATION TEST AND MEASUREMENT CONDITIONS

2.1 General

This section prescribes the conditions under which noise certification tests should be conducted and the measurement procedures that should be used.

Note.- Certifying authorities may approve the use of appropriate “equivalent procedures”. Many applications for a noise certificate involve only minor changes to the aircraft type design. The resultant changes in noise can often be established reliably without the necessity of resorting to a complete test as outlined in this appendix. Also, there are equivalent procedures that may be used in full certification tests,

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in the interest of reducing costs and providing reliable results. Guidance material on the use of equivalent procedures in the noise certification of subsonic jet and propeller-driven aeroplanes and helicopters is provided in the Environmental Technical Manual (Doc 9501), Volume I

- Procedures for the Noise Certification of Aircraft.

2.2 Test environment

2.2.1 Microphone locations

Locations for measuring noise from an aircraft in flight should be surrounded by relatively flat terrain having no excessive sound absorption characteristics such as might be caused by thick, matted, or tall grass, shrubs, or wooded areas. No obstructions which significantly influence the sound field from the aircraft should exist within a conical space above the point on the ground vertically below the microphone, the cone being defined by an axis normal to the ground and by a half-angle 80° from this axis.

Note.— *Those people carrying out the measurements could themselves constitute such obstructions.*

2.2.2 Atmospheric conditions

2.2.2.1 Definitions and specifications


For the purposes of noise certification in this section the following specifications shall apply:

Average crosswind component should be determined from the series of individual values of the “cross track” (v) component of the wind samples obtained during the aircraft test run, using a linear averaging process over 30 seconds or an averaging process that has a time constant of no more than 30 seconds, the result of which is read out at a moment approximately 15 seconds after the time at which the aircraft flight path intercepts the vertical geometrical plane perpendicular to the reference ground track at the centre microphone.

Note. *The reference ground track is defined in 8.1.3.5.*

Average wind speed should be determined from the series of individual wind speed samples obtained during the aircraft test run, using a linear averaging process over 30 seconds, or an averaging process that has a time constant of no more than 30 seconds, the result of which is read out at a moment approximately 15 seconds after the time at which the aircraft passes either over or abeam the microphone. Alternatively, each wind vector should be broken down into its “along track” (u) and “cross-track” (v) components. The u and v components of the series of individual wind samples obtained

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during the aircraft test run should be separately averaged using a linear averaging process over 30 seconds, or an averaging process that has a time constant of no more than 30 seconds, the result of which is read out at a moment approximately 15 seconds after the time at which the aircraft flight path intercepts the vertical geometrical plane perpendicular to the reference ground track at the centre microphone. The average wind speed and direction (with respect to the track) should then be calculated from the averaged u and v components according to Pythagorean Theorem and “arctan(v/u)”.

Distance constant (or response length). The passage of wind (in metres) required for the output of a wind speed sensor to indicate $100 \times (1-1/e)$ per cent (about 63 per cent) of a step-function increase of the input speed.

Maximum crosswind component. The maximum value within the series of individual values of the “cross track” (v) component of the wind samples recorded every second over a time interval that spans the 10 dB-down period.

Maximum wind speed. The maximum value within the series of individual wind speed samples recorded every second over a time interval that spans the 10 dB-down period.

Sound attenuation coefficient. The reduction in level of sound within a one-third octave band, in dB per 100 metres, due to the effects of atmospheric absorption of sound. Equations for the calculation of sound attenuation coefficients from values of atmospheric temperature and relative humidity are provided in Section 7.

Time constant (of a first order system). The time required for a device to detect and indicate $100 \times (1-1/e)$ per cent (about 63 per cent) of a step function change. (The mathematical constant, e, is the base number of the natural logarithm, approximately 2.7183 — also known as Euler’s number, or Napier’s constant.)

Wind direction sample (at a certain moment). The value obtained at that moment from a wind direction sensor/system with characteristics as follows:

Wind speed operating range: 1 m/s (2 kt) to more than 10 m/s (20 kt);


Linearity: ± 5 degrees over the specified range; and

Resolution: 5 degrees.

Note.—For the entire wind sensing system used to obtain wind speed and direction samples, the combined dynamic characteristics, including physical inertia of the sensor(s), and any temporal processing, such as filtering of the sensor signal(s), or smoothing or averaging of the wind sensor data, should be equivalent to a first order system (such as an R/C circuit) with a time constant of no greater than 3 seconds at a wind speed of 5 m/s (10 kt).

Wind speed sample (at a certain moment). The value measured at that moment for

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wind speed using a sensor/system with characteristics as follows:

Range: 1 m/s (2 kt) to more than 10 m/s (20 kt);

Linearity: ± 0.5 m/s (± 1 kt) over the specified range; and

Distance constant (response length): less than 5 metres for systems having dynamic behaviour best characterized by a distance constant; or

Time constant: less than 3 seconds for wind speeds at or above 5 m/s (10 kt) for systems having dynamic behaviour best characterized by a time constant.

Wind vector (at a certain moment). At least once every second the wind vector should be determined. Its magnitude will be represented at a certain moment by the wind speed sample at that moment and the direction of the vector should be represented by the wind direction sample at that moment.

2.2.2.2 Measurement

2.2.2.2.1 Measurements of the ambient temperature and relative humidity should be made at 10 m (33 ft) above the ground. For aeroplanes the ambient temperature and relative humidity should also be determined at vertical increments not greater than 30 m (100 ft) over the sound propagation path. For an aircraft test run to be acceptable, measurements of ambient temperature and relative humidity should be obtained before and after the test run. Both measurements should be representative of the prevailing conditions during the test run and at least one of the measurements of ambient temperature and relative humidity should be within 30 minutes of the test run. The temperature and relative humidity data at the actual time of the test run should be interpolated over time and height, as necessary, from the measured meteorological data.

Note. — The temperature and relative humidity measured at 10 m (33 ft) are assumed to be constant from 10 m (33 ft) to the ground.

2.2.2.2.2 Measurements of wind speed and direction should be made at 10 m (33 ft) above the ground throughout each test run.

2.2.2.2.3 The meteorological conditions at 10 m above the ground should be measured within 2 000 m (6 562 ft) of the microphone locations. They should be representative of the conditions existing over the geographical area in which noise measurements are made.

2.2.2.3 Instrumentation

2.2.2.3.1 Instrumentation for the measurement of temperature and humidity between the

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ground and the aeroplane, including instrumentation for the determination of the height at which these measurements are made, and the manner in which such instrumentation is used should, to the satisfaction of the certifying authority, enable the sampling of atmospheric conditions at 30 m (100 ft) vertical height increments or less.

2.2.2.3.2 All wind speed samples should be taken with the sensor installed such that the horizontal distance between the anemometer and any obstruction is at least 10 times the height of the obstruction. Installation error for the wind direction sensor should be no greater than 5 degrees.

2.2.2.3.3 The instrumentation for noise and meteorological measuring and aircraft flight path tracking should be operated within the environmental limitations specified by the manufacturer.


2.2.2.4 Test window

2.2.2.4.1 For aircraft test runs to be acceptable, they should be carried out under the following atmospheric conditions, except as provided in 2.2.2.4.2:

- a) there should be no precipitation;
- b) the ambient air temperature should not be greater than 35°C and should not be less than –10°C over the sound propagation path between a point 10 m (33 ft) above the ground and the aircraft;
- c) the relative humidity should not be greater than 95 per cent and should not be less than 20 per cent over the sound propagation path between a point 10 m (33 ft) above the ground and the aircraft;
- d) the sound attenuation coefficient in the 8 kHz one-third octave band should not be more than 12 dB/100 m over the sound propagation path between a point 10 m (33 ft) above the ground and the height of the aircraft at PNLTM;

Note—Section 7 of this appendix specifies the method for calculation of sound attenuation coefficients based on temperature and humidity.

- e) for aeroplanes the average wind speed at 10 m (33 ft) above the ground should not exceed 6.2 m/s (12 kt) and the maximum wind speed at 10 m (33 ft) above the ground should not exceed 7.7 m/s (15 kt);
- f) for aeroplanes the average crosswind component at 10 m (33 ft) above the ground should not exceed 3.6 m/s (7 kt) and the maximum crosswind component at 10 m (33 ft) above the ground should not exceed 5.1 m/s (10 kt);

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- g) for helicopters the average wind speed at 10 m (33 ft) above the ground should not exceed 5.1 m/s (10 kt);
- h) for helicopters the average crosswind component at 10 m (33 ft) above the ground should not exceed 2.6 m/s (5 kt); and
- i) there should be no anomalous meteorological or wind conditions that would significantly affect the measured noise levels.

Note—The noise certification test windows for wind speed expressed in m/s are the result of converting historically used values expressed in knots using a conversion factor consistent with Part 5, Chapter 3, Table 3-3, and rounded to 0.1 m/s. The values as given here, expressed in either unit, are considered equivalent for establishing adherence to the wind speed test windows for noise certification purposes.

2.2.2.4.2 For helicopters the requirements of 2.2.2.4.1 b), c) and d) should only apply at 10 m (33 ft) above the ground.


2.2.2.5 Layering

2.2.2.5.1 For each aeroplane test run the sound attenuation coefficient in the 3 150 Hz one-third octave band should be determined at the time of PNLTM from 10 m (33 ft) above the ground to the height of the aeroplane, with vertical height increments not greater than 30 m (100 ft).

2.2.2.5.2 If the individual values of the sound attenuation coefficient in the 3 150 Hz one-third octave band associated with the vertical height increments specified in 2.2.2.5.1 do not vary by more than 0.5 dB/100 m relative to the value determined at 10 m (33 ft), the coefficient to be used in the adjustment of the aeroplane noise levels for each one-third octave band should be the average of the coefficient calculated from the temperature and humidity at 10 m (33 ft) above the ground and the coefficient calculated from the temperature and humidity at the height of the test aeroplane.

2.2.2.5.3 If the individual values of the sound attenuation coefficient in the 3 150 Hz one-third octave band associated with the vertical height increments specified in 2.2.2.5.1 vary by more than 0.5 dB/100 m relative to the value determined at 10 m (33 ft), then “layered” sections of the atmosphere should be used, as described below, in the computation of the coefficient for each one-third octave band to be used in the adjustment of the aeroplane noise levels:

- a) the atmosphere from the ground to at least the height of the aeroplane should be divided into layers of 30 m (100 ft) depth;
- b) for each of the layers specified in 2.2.2.5.3 a), the sound attenuation coefficient should be determined for each one-third octave band; and
- c) for each one-third octave band the sound attenuation coefficient to be used in the adjustment of the aeroplane noise levels should be the average of the individual

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layer coefficients specified in 2.2.2.5.3 b).

2.2.2.5.4 For helicopters, the sound attenuation coefficient to be used in the adjustment of noise levels for each one-third octave band should be calculated from the temperature and humidity at 10 m (33 ft) above the ground.

2.3 Flight path measurement

2.3.1 The aircraft height and lateral position relative to the flight track should be determined by a method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation or photographic scaling techniques, to be approved by the certificating authority.

2.3.2 The aircraft position along the flight path should be related to the noise recorded at the noise measurement locations by means of synchronizing signals over a distance sufficient to assure adequate data during the period that the noise is within 10 dB of the maximum value of PNLT.

2.3.3 Position and performance data required to make the adjustments referred to in Section 8 of this appendix should be automatically recorded at an approved sampling rate. Measuring equipment should be approved by the certificating authority.

3. MEASUREMENT OF AIRCRAFT NOISE RECEIVED ON THE GROUND

3.1 Definitions

For the purposes of this section the following definitions shall apply:

Ambient noise. The acoustical noise from sources other than the test aircraft present at the microphone site during aircraft noise measurement. Ambient noise is one component of background noise.

Background noise. The combined noise present in a measurement system from sources other than the test aircraft, which can influence or obscure the aircraft noise levels being measured. Typical elements of background noise include (but are not limited to): ambient noise from sources around the microphone site; thermal electrical noise generated by components in the measurement system; magnetic flux noise (“tape hiss”) from analogue tape recorders; and digitization noise caused by quantization error in digital converters. Some elements of background noise, such as digitization noise, can obscure the aircraft noise signal, while others, such as ambient noise, can also contribute energy to the measured aircraft noise signal.

Broadband noise. Noise for which the frequency spectrum is continuous (i.e. energy is present at all frequencies in a given range) and which lacks any discrete frequency

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components (i.e. tones).

Calibration check frequency. In hertz, the nominal frequency of the sinusoidal sound pressure signal produced by the sound calibrator.

Calibration sound pressure level. In decibels, the sound pressure level produced, under reference environmental conditions, in the cavity of the coupler of the sound calibrator that is used to determine the overall acoustical sensitivity of a measurement system.

Free-field sensitivity level of a microphone system. In decibels, twenty times the logarithm to the base ten of the ratio of the free-field sensitivity of a microphone system and the reference sensitivity of one volt per pascal. The free-field sensitivity level of a microphone system may be determined by subtracting the sound pressure level (in decibels re 20 μ Pa) of the sound incident on the microphone from the voltage level (in decibels re 1 V) at the output of the microphone system, and adding 93.98 dB to the result.

Free-field sensitivity of a microphone system. In volts per pascal, for a sinusoidal plane progressive sound wave of specified frequency, at a specified sound-incident angle, the quotient of the root-mean-square voltage at the output of a microphone system and the root-mean-square sound pressure that would exist at the position of the microphone in its absence.

Level difference. In decibels, for any nominal one-third octave midband frequency, the output signal level measured on any level range minus the level of the corresponding electrical input signal.

Level non-linearity. In decibels, the level difference measured on any level range, at a stated one-third octave nominal midband frequency, minus the corresponding reference level difference, all input and output signals being relative to the same reference quantity.

Level range. In decibels, an operating range determined by the setting of the controls that are provided in a measurement system for the recording and one-third octave band analysis of a sound pressure signal. The upper boundary associated with any particular level range should be rounded to the nearest decibel.

Linear operating range. In decibels, for a stated level range and frequency, the range of levels of steady sinusoidal electrical signals applied to the input of the entire measurement system, exclusive of the microphone but including the microphone preamplifier and any other signal-conditioning elements that are considered to be part of the microphone system, extending from a lower to an upper boundary, over which

the level non-linearity is within specified tolerance limits. It is not necessary to include microphone extension cables as configured in the field.

Measurement system. The combination of instruments used for the measurement of sound pressure levels, including a sound calibrator, windscreen, microphone system, signal recording and conditioning devices, and a one-third octave band analysis system. Practical installations may include a number of microphone systems, the outputs from which are recorded simultaneously by a multi-channel recording/analysis device via signal conditioners as appropriate. For the purpose of this section, each complete measurement channel is considered to be a measurement system to which the requirements apply accordingly.

Microphone system. The components of the measurement system which produce an electrical output signal in response to a sound pressure input signal, and which generally include a microphone, a preamplifier, extension cables, and other devices as necessary.

Reference direction. In degrees, the direction of sound incidence specified by the manufacturer of the microphone, relative to a sound incidence angle of 0°, for which the free-field sensitivity level of the microphone system is within specified tolerance limits.

Reference level difference. In decibels, for a stated frequency, the level difference measured on a level range for an electrical input signal corresponding to the calibration sound pressure level, adjusted as appropriate, for the level range.

Reference level range. In decibels, the level range for determining the acoustical sensitivity of the measurement system and containing the calibration sound pressure level.

Sound incidence angle. In degrees, an angle between the principal axis of the microphone and a line from the sound source to the center of the diaphragm of the microphone. When the sound incidence angle is 0°, the sound is said to be received at the microphone at “normal (perpendicular) incidence”; when the sound incidence angle is 90°, the sound is said to be received at “grazing incidence”. The principal axis of a measurement microphone is through the centre of the diaphragm and perpendicular to it.

Time-average band sound pressure level. In decibels, ten times the logarithm to the base ten, of the ratio of the time mean-square of the instantaneous sound pressure during a stated time interval and in a specified one-third octave band, to the square of the reference sound pressure of 20 µPa.

Windscreen insertion loss. In decibels, at a stated nominal one-third octave midband frequency, and for a stated sound incidence angle on the inserted microphone, the indicated sound pressure level without the windscreen installed around the microphone minus the sound pressure level with the windscreen installed.

3.2 Reference environmental conditions

The reference environmental conditions for specifying the performance of a measurement system shall be:

- air temperature 23°C
- static air pressure 101.325 kPa
- relative humidity 50 per cent.

3.3 General

Note—Measurements of aircraft noise that utilize instruments that conform to the specifications of this section yield one-third octave band sound pressure levels as a function of time, for the calculation of the effective perceived noise level as described in Section 4.

3.3.1 The measurement system should consist of equipment approved by the certificating authority and equivalent to the following:

- a) a windscreen (see 3.4);
- b) a microphone system (see 3.5);
- c) a recording and reproducing system to store the measured aircraft noise signals for subsequent analysis (see 3.6);
- d) a one-third octave band analysis system (see 3.7); and
- e) calibration systems to maintain the acoustical sensitivity of the above systems within specified tolerance limits (see 3.8).

3.3.2 For any component of the measurement system that converts an analogue signal to digital form, such conversion should be performed so that the levels of any possible aliases or artefacts of the digitization process will be less than the upper boundary of the linear operating range by at least 50 dB at any frequency less than 12.5 kHz. The sampling rate should be at least 28 kHz. An anti-aliasing filter should be included before the digitization process.

3.4 Windscreen

In the absence of wind and for sinusoidal sounds at grazing incidence, the insertion loss caused by the windscreen of a stated type installed around the microphone should not exceed ± 1.5 dB at nominal one-third octave midband frequencies from 50 Hz to 10 kHz inclusive.

3.5 Microphone system

3.5.1 The microphone system should conform to the specifications in 3.5.2 to 3.5.4. Various microphone systems may be approved by the certificating authority on the basis of demonstrated equivalent overall electroacoustical performance. Where two or more microphone systems of the same type are used, demonstration that at least one system conforms to the specifications in full is sufficient to demonstrate conformance.

Note. — This demonstration of equivalent performance does not eliminate the need to calibrate and check each system as defined in 3.9.

3.5.2 The microphone should be mounted with the sensing element 1.2 m (4 ft) above the local ground surface and should be oriented for grazing incidence, i.e. with the sensing element substantially in the plane defined by the predicted reference flight path of the aircraft and the measuring station. The microphone mounting arrangement should minimize the interference of the supports with the sound to be measured. Figure A2-1 illustrates sound incidence angles on a microphone.

3.5.3 The free-field sensitivity level of the microphone and preamplifier in the reference direction, at frequencies over at least the range of one-third octave nominal midband frequencies from 50 Hz to 5 kHz inclusive, should be within ± 1.0 dB of that at the calibration check frequency, and within ± 2.0 dB for nominal midband frequencies of 6.3 kHz, 8 kHz and 10 kHz.

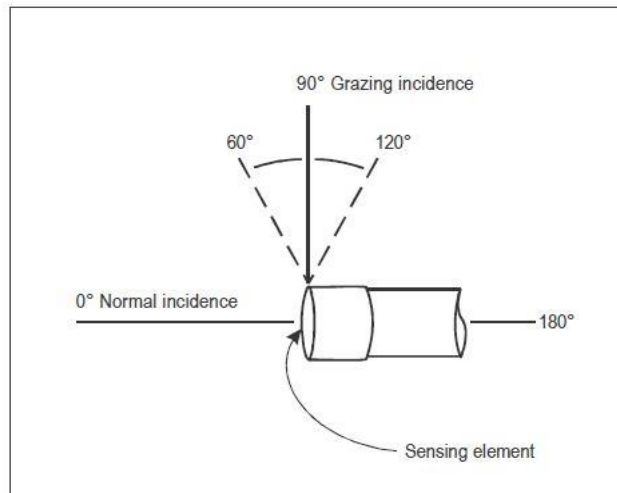


Figure A2-1. Illustration of sound incidence angles on a microphone

3.5.4 For sinusoidal sound waves at each one-third octave nominal midband frequency over the range from 50 Hz to 10 kHz inclusive, the free-field sensitivity levels of the microphone system at sound incidence angles of 30°, 60°, 90°, 120° and 150° should not differ from the free-field sensitivity level at a sound incidence angle of 0° (“normal incidence”) by more than the values shown in Table A2-1. The free-field sensitivity level differences at sound incidence angles between any two adjacent sound incidence angles in Table A2-1 should not exceed the tolerance limit for the greater angle.

3.6 Recording and reproducing systems

3.6.1 A recording and reproducing system, such as a digital or analogue magnetic tape recorder, a computer-based system or other permanent data storage device, should be used to store sound pressure signals for subsequent analysis. The sound produced by the aircraft should be recorded in such a way that a record of the complete acoustical signal is retained. The recording and reproducing systems should conform to the specifications in 3.6.2 to 3.6.9 at the recording speeds and/or data sampling rates used for the noise certification tests. Conformance should be demonstrated for the frequency bandwidths and recording channels selected for the tests.

3.6.2 The recording and reproducing systems should be calibrated as described in 3.9. For aircraft noise signals for which the high frequency spectral levels decrease rapidly with increasing frequency, appropriate pre-emphasis and complementary de-emphasis networks may be included in the measurement system. If pre-emphasis is included, over the range of nominal one-third octave midband frequencies from 800 Hz to 10 kHz inclusive, the electrical gain provided by the pre-emphasis network shall not exceed 20

dB relative to the gain at 800 Hz.

- 3.6.3 For steady sinusoidal electrical signals applied to the input of the entire measurement system exclusive of the microphone system, but including the microphone preamplifier, and any other signal- conditioning elements that are considered to be part of the microphone system, at a selected signal level within 5 dB of that corresponding to the calibration sound pressure level on the reference level range, the time average signal level indicated by the readout device at any one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive should be within ± 1.5 dB of that at the calibration check frequency. The frequency response of a measurement system, which includes components that convert analogue signals to digital form, should be within ± 0.3 dB of the response at 10 kHz over the frequency range from 10 kHz to 11.2 kHz. It is not necessary to include microphone extension cables as configured in the field
- 3.6.4 For analogue tape recordings, the amplitude fluctuations of a 1 kHz sinusoidal signal recorded within 5 dB of the level corresponding to the calibration sound pressure level should not vary by more than ± 0.5 dB throughout any reel of the type of magnetic tape utilized. Conformance to this requirement should be demonstrated using a device which has time-averaging properties equivalent to those of the spectrum analyser.
- 3.6.5 For all appropriate level ranges and for steady sinusoidal electrical signals applied to the input of the measurement system exclusive of the microphone system, but including the microphone preamplifier, and any other signal-conditioning elements that are considered to be part of the microphone system, at one-third octave nominal midband frequencies of 50 Hz, 1 kHz and 10 kHz, and the calibration check frequency, if it is not one of these frequencies, the level non-linearity should not exceed ± 0.5 dB for a linear operating range of at least 50 dB below the upper boundary of the level range. It is not necessary to include microphone extension cables as configured in the field.

Table A2-1. Microphone directional response requirements

Nominal midband frequency kHz	Maximum difference between the free-field sensitivity level of a microphone system at normal incidence and the free-field sensitivity level at specified sound incidence angles (dB)				
	Sound incidence angle degrees				
	30	60	90	120	150
0.05 to 1.6	0.5	0.5	1.0	1.0	1.0
2.0	0.5	0.5	1.0	1.0	1.0
2.5	0.5	0.5	1.0	1.5	1.5
3.15	0.5	1.0	1.5	2.0	2.0
4.0	0.5	1.0	2.0	2.5	2.5
5.0	0.5	1.5	2.5	3.0	3.0
6.3	1.0	2.0	3.0	4.0	4.0
8.0	1.5	2.5	4.0	5.5	5.5
10.0	2.0	3.5	5.5	6.5	7.5

- IEC 61265:1995 entitled “Electroacoustics - Instruments for measurement of aircraft noise - Performance requirements for systems to measure one-third-octave band sound pressure levels in noise certification of transport-category aeroplanes”. This IEC publication may be obtained from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.


3.6.6 On the reference level range, the level corresponding to the calibration sound pressure level should be at least 5 dB, but no more than 30 dB less than the upper boundary of the level range.

3.6.7 The linear operating ranges on adjacent level ranges should overlap by at least 50 dB minus the change in attenuation introduced by a change in the level range controls. It is possible for a measurement system to have level range controls that permit attenuation changes of, for example, either 10 dB or 1 dB. With 10 dB steps, the minimum overlap required would be 40 dB, and with 1 dB steps the minimum overlap would be 49 dB.

3.6.8 Provision should be made for an overload indication to occur during an overload condition on any relevant level range.

3.6.9 Attenuators included in the measurement system to permit range changes should operate in known intervals of decibel steps.

3.7 Analysis systems

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- 3.7.1 The analysis system should conform to the specifications in 3.7.2 to 3.7.7 for the frequency bandwidths, channel configurations and gain settings used for analysis.
- 3.7.2 The output of the analysis system should consist of one-third octave band sound pressure levels as a function of time, obtained by processing the noise signals (preferably recorded) through an analysis system with the following characteristics:
- a) a set of 24 one-third octave band filters, or their equivalent, having nominal midband frequencies from 50 Hz to 10 kHz inclusive;
 - b) response and averaging properties in which, in principle, the output from any one-third octave filter band is squared, averaged and displayed or stored as time-averaged sound pressure levels;
 - c) the interval between successive sound pressure level samples should be 500 ms \pm 5 ms for spectral analysis with or without SLOW-time-weighting;
 - d) for those analysis systems that do not process the sound pressure signals during the period of time required for readout and/or resetting of the analyser, the loss of data should not exceed a duration of 5 ms; and
 - e) the analysis system should operate in real time from 50 Hz to at least 12 kHz inclusive. This requirement applies to all operating channels of a multichannel spectral analysis system.
- 3.7.3 The one-third octave band analysis system should conform to the class 1 performance requirements of IEC 61260² as amended, over the range of one-third octave filters having nominal midband frequencies from 50 Hz to 10 kHz inclusive. The substitution of an analysis system that complies with class 2 as an alternative to class 1 electrical performance requirements of IEC 61260 shall be subject to approval of the certifying authority.

Tests of the one-third octave band analysis system should be made according to the methods described in IEC 61260-3³ or by an equivalent procedure approved by the certificating authority, for relative attenuation, anti-aliasing filters, real-time operation, level linearity, and filter integrated response (effective bandwidth).

1. IEC 61265:1995 entitled “Electroacoustics — Instruments for measurement of aircraft noise — Performance requirements for systems to measure one-third-octave band sound pressure levels in noise certification of transport-category aeroplanes”. This IEC publication may be obtained from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.
2. IEC 61260-1:1995/2014 entitled “Electroacoustics — Octave-band and fractional-octave-band filters – Part 1: Specifications”. This IEC publication may be obtained from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.
3. IEC 61260-3:2016 entitled “Electroacoustics — Octave-band and fractional-octave-band filters – Part 3: Periodic tests”. This IEC publication may be obtained from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.

3.7.4 When SLOW-time-averaging is performed in the analyser, the response of the one-third octave band analysis system to a sudden onset or interruption of a constant sinusoidal signal at the respective one-third octave nominal midband frequency should be measured at sampling instants 0.5, 1, 1.5 and 2 seconds after both the onset and the interruption. The rising response should be -4 ± 1 dB at 0.5 seconds, -1.75 ± 0.75 dB at 1 second, -1 ± 0.5 dB at 1.5 seconds and -0.5 ± 0.5 dB at 2 seconds relative to the steady-state level. The sum of the rising and corresponding falling response shall be -6.5 ± 1 dB, at both 0.5 and 1 seconds. The sum of the rising and falling responses should be -6.5 dB or less at 1.5 seconds and -7.5 dB or less at 2 seconds, and subsequent times relative to the steady-state levels. This equates to an exponential averaging process (SLOW weighting) with a nominal 1-second time .

3.7.5 When the one-third octave band sound pressure levels are determined from the output of the analyser without SLOW-time-weighting, SLOW-time-weighting should be simulated in the subsequent processing. Simulated SLOW-weighted sound pressure levels can be obtained using a continuous exponential averaging process by the following equation:

$$L_s(j,k) = 10 \log [(0.60653) 10^{0.1L [i,(k-1)]} + (0.39347) 10^{0.1L(i,k)}]$$

where $L_s(j,k)$ is the simulated SLOW-weighted sound pressure level and $L (i,k)$ is the as-measured 0.5 seconds time average sound pressure level determined from the output of the analyser for the k -th instant of time and the i -th one-third octave band. For $k = 1$, the SLOW-weighted sound pressure $L_s[j,(k-1 = 0)]$ on the right-hand side should be set to 0 dB.

An approximation of the continuous exponential averaging is represented by the

following equation for a four sample averaging process for $k = 4$:

$$L_s(i,k) = 10 \log [(0.13) 10^{0.1L[i,(k-3)]} + (0.21) 10^{0.1L[i,(k-2)]} + (0.27) 10^{0.1L[i,(k-1)]} + (0.39) 10^{0.1L[i,k]}]$$

where $L_s(i,k)$ is the simulated SLOW-weighted sound pressure level and $L(i,k)$ is the as-measured 0.5 seconds time average sound pressure level determined from the output of the analyser for the k -th instant of time and the i -th one-third octave band.

The sum of the weighting factors is 1.0 in the two equations. Sound pressure levels calculated by means of either equation are valid for the sixth and subsequent 0.5 seconds data samples, or for times greater than 2.5 seconds after initiation of data analysis.

Note.- The coefficients in the two equations were calculated for use in determining equivalent SLOW-weighted sound pressure levels from samples of 0.5 seconds time average sound pressure levels. The equations should not be used with data samples where the averaging time differs from 0.5 seconds.

- 3.7.6 The instant in time by which a SLOW-time-weighted sound pressure level is characterized should be 0.75 seconds earlier than the actual readout time.

Note.- The definition of this instant in time is required to correlate the recorded noise with the aircraft position when the noise was emitted and takes into account the averaging period of the SLOW weighting. For each one-half second data record this instant in time may also be identified as 1.25 seconds after the start of the associated 2-second averaging period.

- 3.7.7 The resolution of the sound pressure levels, both displayed and stored, should be 0.1 dB or better.

3.8 Calibration instrumentation

- 3.8.1 All instrumentation used for calibration and determination of corrections should be approved by the certificating authority.

- 3.8.2 The sound calibrator should at least conform to the class 1 requirements of IEC 60942.³ The sound pressure level produced in the cavity of the coupler of the sound calibrator should be calculated for the test environmental conditions using the manufacturer's supplied information on the influence of atmospheric air pressure and temperature. The output of the sound calibrator should be determined within six months of each aircraft noise measurement by a method traceable to a national standards laboratory. Tolerable changes in output from the previous calibration should be not more than 0.2 dB.

- 3.8.3 If pink noise is used to determine the corrections for system frequency response in 3.9.7, then the output of the noise generator should be determined within six months

of each aircraft noise measurement by a method traceable to a national standards laboratory. Tolerable changes in the relative output from the previous calibration in each one-third octave band should be not more than 0.2 dB.

3.9 Calibration and checking of system

- 3.9.1 Calibration and checking of the measurement system and its constituent components should be carried out to the satisfaction of the certificating authority by the methods specified in 3.9.2 to 3.9.9. All calibration corrections and adjustments, including those for the environmental effects on sound calibrator output level, should be reported to the certificating authority and applied to the measured one third octave sound pressure levels determined from the output of the analyser. Aircraft noise data collected during an overload condition of any measurement system components in the signal path prior to and including the recorder are invalid and should not be used. If the overload condition occurred during analysis or at a point in the signal path after the recorder, the analysis should be repeated with reduced sensitivity to eliminate the overload.
- 3.9.2 The acoustical sensitivity of the measurement system should be established using a sound calibrator generating a known sound pressure level at a known frequency. Sufficient sound pressure level calibrations should be recorded during each test day to ensure that the acoustical sensitivity of the measurement system is known for the prevailing environmental conditions corresponding with each aircraft noise measurement. Measured aircraft noise data should not be considered valid for certification purposes unless preceded and succeeded by valid sound pressure level calibrations. The measurement system should be considered satisfactory if the difference between the acoustical sensitivity levels recorded immediately before and immediately after each group of aircraft noise measurements on a given day is not greater than 0.5 dB. The 0.5 dB limit applies after any atmospheric pressure corrections have been applied to the calibrator output level. The arithmetic mean of the preceding and succeeding calibrations should be used to represent the acoustical sensitivity level of the measurement system for each group of aircraft noise measurements. The calibration corrections should be reported to the certificating authority and applied to the measured one-third octave band sound pressure levels determined from the output of the analyser.
- 3.9.3 For analogue (direct or FM) magnetic tape recorders each volume of recording medium, such as a reel, cartridge, or cassette, should carry a sound pressure level calibration of at least 10 seconds duration at its beginning and end.
- 3.9.4 The free-field frequency response of the microphone system may be determined by using an electrostatic actuator in combination with the manufacturer’s data or by testing in an anechoic free-field facility. The corrections for frequency response should be determined within 90 days of each aircraft noise measurement and should be reported to the certificating authority. They should be applied to the measured one-

third octave band sound pressure levels determined from the output of the analyser.

3.9.5 When the angles of incidence at the microphone of sound emitted from the aircraft are within $\pm 30^\circ$ of grazing incidence (see Figure A2-1), a single set of free-field corrections based on grazing incidence shall be considered sufficient for the correction of directional response effects. Otherwise appropriate corrections for incidence effects should be determined at the angle of incidence for each one-half second sample. Such corrections should be reported to the certificating authority and applied to the measured one third octave band sound pressure levels determined from the output of the analyser.

Note: IEC 60942:2003 entitled “Electroacoustics — Sound calibrators”. This IEC publication may be obtained from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.

3.9.6 Free-field insertion effects of the windscreen for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive should be determined with sinusoidal sound signals at appropriate incidence angles on the inserted microphone. For a windscreen which is undamaged and uncontaminated, the insertion effects may be taken from the manufacturer’s data. In addition, the insertion effects of the windscreen may be determined within six months of each aircraft noise measurement by a method traceable to a national standards laboratory. Tolerable changes in the insertion effects from the previous calibration at each one-third octave frequency band should be not more than 0.4 dB. The corrections for the free-field insertion effects of the windscreen should be reported to the certificating authority and applied to the measured one-third octave sound pressure levels determined from the output of the analyser.

3.9.7 The frequency response of the entire measurement system, exclusive of the microphone and windscreen, but otherwise configured as deployed in the field during the aircraft noise measurements, should be established. Corrections should be determined for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive. The determination should be made at a level within 5 dB of the level corresponding to the calibration sound pressure level on the reference level range and should utilize pink random or pseudo-random noise or alternatively discrete sine or swept sine signals. The corrections for frequency response should be reported to the certificating authority and applied to the measured one-third octave sound pressure levels determined from the output of the analyser. If the system frequency response corrections are determined away from the field then frequency response testing should be performed in the field to ensure the integrity of the measurement system.

3.9.8 For analogue (direct or FM) magnetic tape recorders, each volume of recording medium such as a reel, cartridge, or cassette should carry at least 30 seconds of pink random or pseudo-random noise at its beginning and end. Aircraft noise data obtained from

analogue tape-recorded signals should be accepted as valid only if level differences in the 10 kHz one-third octave band are not more than 0.75 dB for the signals recorded at the beginning and end. For systems using analogue (direct or FM) magnetic tape recorders frequency response corrections should be determined from pink noise recordings performed in the field during deployment for aircraft noise measurements.

- 3.9.9 The performance of switched attenuators in the equipment used during noise certification measurements and calibration should be checked within six months of each aircraft noise measurement to ensure that the maximum error does not exceed 0.1 dB. The accuracy of gain-changes should be tested or determined from manufacturers specifications to the satisfaction of the certifying authority.

3.10 Adjustments for background noise

- 3.10.1 Background noise should be recorded (for at least 30 seconds) at the measurement points with the system gain set at the levels used for the aircraft noise measurements. The recorded background noise sample should be representative of that which exists during the test run. The recorded aircraft noise data should be accepted only if the background noise levels, when analysed in the same way and quoted in PNL (see 4.1.3 a)), are at least 20 dB below the maximum PNL of the aircraft.
- 3.10.2 Aircraft sound pressure levels within the 10 dB-down points (see 4.5.1) should exceed mean background noise levels determined above by at least 3 dB in each one-third octave band or be adjusted using a method similar to that described in the section of the *Environmental Technical Manual* (Doc 9501), Volume I – *Procedures for the Noise Certification of Aircraft* concerning the adjustment of aircraft noise levels for the effect of background noise.

4. CALCULATION OF EFFECTIVE PERCEIVED NOISE LEVEL FROM MEASURED NOISE DATA

4.1 General

4.1.1 The metric used to quantify the certificated noise level should be the effective perceived noise level (EPNL) expressed in units of EPNdB.

Note: EPNL is a single number evaluator taking into account the subjective effects of aircraft noise on human beings. It consists of the instantaneous perceived noise level, PNL, adjusted for spectral irregularities and for duration.

4.1.2 In order to derive the EPNL, three basic physical properties of the aircraft noise should be measured: level, frequency distribution and variation over time. This requires the acquisition of the instantaneous sound pressure levels in spectra composed of 24 one-third octave bands, which should be obtained for each one-half second increment of time throughout the duration over which the aircraft noise is measured.

4.1.3 The calculation procedure which utilizes physical measurements of noise to derive the EPNL evaluation measure of subjective response should consist of the five following steps:

- a) each of the 24 one-third octave band sound pressure levels in each measured one-half second spectrum is converted to perceived noisiness by the method of Section 4.7. The noy values are combined and then converted to instantaneous perceived noise level, $PNL(k)$ for each spectrum, measured at the k -th instant of time, by the method of Section 4.2;
- b) for each spectrum a tone correction factor, $C(k)$, is calculated by the method of Section 4.3 to account for the subjective response to the presence of spectral irregularities;
- c) the tone correction factor is added to the perceived noise level to obtain the tone corrected perceived noise level, $PNLT(k)$, for each spectrum:

$$PNLT(k) = PNL(k) + C(k);$$

- d) the history of $PNLT(k)$ noise levels is examined to identify the maximum value, $PNLTM$ as determined by the method of Section 4.4, and noise duration as determined by the method of Section 4.5; and
- e) effective perceived noise level, EPNL, is determined by logarithmic summation of the $PNLT$ levels over the noise duration, and normalizing the duration to 10 seconds, by the method of Section 4.6.

4.2 Perceived noise level

Instantaneous perceived noise levels, $PNL(k)$, should be calculated from instantaneous one-third octave band sound pressure levels, $SPL(i,k)$, as follows:

Step 1. Convert each one-third octave band, $SPL(i,k)$, from 50 to 10 000 Hz, to perceived noisiness, $n(i,k)$, by reference to the mathematical formulation of noy tables given in Section 4.7 or to the section in the *Environmental Technical Manual* (Doc 9501), Volume I - *Procedures for the Noise Certification of Aircraft*, concerning reference tables used in the manual calculation of effective perceived noise level.

Step 2. Combine the perceived noisiness values, $n(i,k)$, found in Step 1 by the following formula:

$$N(k) = n(k) + 0.15 \left\{ \left[\sum_{i=1}^{24} n(i, k) \right] - n(k) \right\}$$

$$= 0.85 n(k) + 0.15 \sum_{i=1}^{24} n(i, k)$$

where $n(k)$ is the largest of the 24 values of $n(i,k)$, and $N(k)$ is the total perceived noisiness.

Step 3. Convert the total perceived noisiness, $N(k)$, into perceived noise level, $PNL(k)$, by the following formula:

$$PNL(k) = 40.0 + \frac{10}{\log 2} \log N(k)$$

Note. - Perceived noise level, $PNL(k)$, as a function of total perceived noisiness is plotted in the section of the *Environmental Technical Manual* (Doc 9501), Volume I – *Procedures for the Noise Certification of Aircraft*, concerning reference tables used in the manual calculation of effective perceived noise level.

4.3 Correction for spectral irregularities

4.3.1 Noise having pronounced spectral irregularities (for example, the maximum discrete frequency components or tones) should be adjusted by the correction factor, $C(k)$, calculated as follows:

Step 1. Except for helicopters and tilt-rotors which start at 50 Hz (band number 1), start with the corrected sound pressure level in the 80 Hz one-third octave band (band number 3), calculate the changes in sound pressure level (or “slopes”) in the remainder of the one-third octave bands as follows:

$s(3,k) = \text{no value}$

$$s(4,k) = \text{SPL}(4,k) - \text{SPL}(3,k)$$

-
-
-

$$s(i,k) = \text{SPL}(i,k) - \text{SPL}(i-1,k)$$

-
-
-

$$s(24,k) = \text{SPL}(24,k) - \text{SPL}(23,k)$$

Step 2. Encircle the value of the slope, $s(i,k)$, where the absolute value of the change in slope is greater than five; that is, where:

$$|\Delta s(i,k)| = |s(i,k) - s(i-1,k)| > 5$$

Step 3.

- a) If the encircled value of the slope $s(i,k)$ is positive and algebraically greater than the slope $s(i-1,k)$, encircle $\text{SPL}(i,k)$.
- b) If the encircled value of the slope $s(i,k)$ is zero or negative and the slope $s(i-1,k)$ is positive, encircle $\text{SPL}(i-1,k)$.
- c) For all other cases, no sound pressure level value is to be encircled.

Step 4. Compute new adjusted sound pressure levels, $\text{SPL}(i,k)$, as follows:

- a) For non-encircled sound pressure levels, let the new sound pressure levels equal the original sound pressure levels, $\text{SPL}(i,k) = \text{SPL}(i,k)$.
- b) For encircled sound pressure levels in bands 1 to 23 inclusive, let the new sound pressure level equal the arithmetic average of the preceding and following sound pressure levels:

$$\text{SPL}(i,k) = \frac{1}{2} [\text{SPL}(i-1,k) + \text{SPL}(i+1,k)]$$

- c) If the sound pressure level in the highest frequency band ($i = 24$) is encircled, let the new sound pressure level in that band equal:

$$\text{SPL}(24,k) = \text{SPL}(23,k) + s(23,k)$$

Step 5. Recompute new slopes $s(i,k)$, including one for an imaginary 25th band, as follows:

$$s(3,k) = s(4,k)$$

$$s(4,k) = \text{SPL}(4,k) - \text{SPL}(3,k)$$

-
-
-

$$s(i,k) = \text{SPL}(i,k) - \text{SPL}(i-1,k)$$

-
-
-

$$s(24,k) = \text{SPL}(24,k) - \text{SPL}(23,k) \quad s(25,k) = s(24,k)$$

Step 6. For i from 3 to 23 (or 1 to 23 for helicopters), compute the arithmetic average of the three adjacent slopes as follows:

$$\bar{s}(i,k) = \frac{1}{3} [s(i,k) + s(i+1,k) + s(i+2,k)]$$

Step 7. Compute final one-third octave-band sound pressure levels, $\text{SPL}(i,k)$, by beginning with band number 3 (or band number 1 for helicopters) and proceeding to band number 24 as follows:

$$\text{SPL}(3,k) = \text{SPL}(3,k) \quad \text{SPL}(4,k) = \text{SPL}(3,k) + \bar{s}(3,k)$$


-
-
-

$$\text{SPL}(i,k) = \text{SPL}(i-1,k) + \bar{s}(i-1,k)$$

-
-
-

$$\text{SPL}(24,k) = \text{SPL}(23,k) + \bar{s}(23,k)$$

Step 8. Calculate the differences, $F(i,k)$, between the original sound pressure level and the final broadband sound pressure level as follows:

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$$F(i,k) = \text{SPL}(i,k) - \text{SPL}(i,k)$$

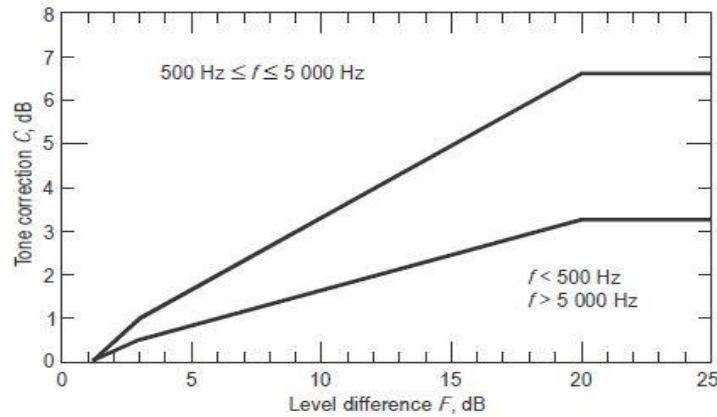
and note only values equal to or greater than one and a half.

Step 9. For each of the relevant one-third octave bands (3 to 24), determine tone correction factors from the sound pressure level differences, $F(i,k)$, and Table A2-2.

Step 10. Designate the largest of the tone correction factors, determined in Step 9, as $C(k)$. An example of the tone correction procedure is given in the section of the *Environmental Technical Manual* (Doc 9501), Volume I - *Procedures for the Noise Certification of Aircraft*, concerning reference tables used in the manual calculation of effective perceived noise level.



Table A2-2. Tone correction factors



Frequency f , Hz	Level difference F , dB	Tone correction C , dB
$50 \leq f < 500$	$1\frac{1}{2}^* \leq F < 3$	$F/3 - \frac{1}{2}$
	$3 \leq F < 20$	$F/6$
	$20 \leq F$	$3\frac{1}{3}$
$500 \leq f \leq 5\ 000$	$1\frac{1}{2}^* \leq F < 3$	$2 F/3 - 1$
	$3 \leq F < 20$	$F/3$
	$20 \leq F$	$6\frac{2}{3}$
$5\ 000 < f \leq 10\ 000$	$1\frac{1}{2}^* \leq F < 3$	$F/3 - \frac{1}{2}$
	$3 \leq F < 20$	$F/6$
	$20 \leq F$	$3\frac{1}{3}$

* See Step 8 of 4.3.1.

Tone corrected perceived noise levels $PNLT(k)$ should be determined by adding the $C(k)$ values to corresponding $PNL(k)$ values, that is:

$$PNLT(k) = PNL(k) + C(k)$$

For any i -th one-third octave band, at any k -th increment of time, for which the tone correction factor is suspected to result from something other than (or in addition to) an actual tone (or any spectral irregularity other than aircraft noise), an additional analysis may be made using a filter with a bandwidth narrower than one-third of an octave. If the narrow band analysis corroborates these suspicions, then a revised value for the broadband sound pressure level, $SPL(i,k)$, may be determined from the narrow band analysis and used to compute a revised tone correction factor for that particular one-third octave band. Other methods of rejecting spurious tone corrections such as those described in Chapter 4 of the Environmental Technical Manual (Doc 9501), Volume I – Procedures for the Noise Certification of Aircraft may be used.

4.3.2 This procedure will underestimate EPNL if an important tone is of a frequency such that it is recorded in two adjacent one-third octave bands. It should be demonstrated to the satisfaction of the certificating authority: *either* that this has not occurred, *or* that if it has occurred that the tone correction has been adjusted to the value it would have had if the tone had been recorded fully in a single one-third octave band.

4.4 Maximum tone corrected perceived noise level

4.4.1 The tone corrected perceived noise levels, $PNLT(k)$, shall be calculated from measured one-half second values of SPL in accordance with the procedure of Section 4.3. The maximum tone corrected perceived noise level, $PNLTM$, should be the maximum value of $PNLT(k)$, adjusted if necessary for the presence of bandsharing by the method of Section 4.4.2. The increment associated with $PNLTM$ is designated as k_M .

Note.- Figure A2-2 is an example of a flyover noise time history where the maximum value is clearly indicated.

4.4.2 The tone at $PNLTM$ may be suppressed due to one-third octave band sharing of that tone. To identify whether this is the case, the average of the tone correction factors of the $PNLTM$ spectrum and the two preceding and two succeeding spectra shall be calculated. If the value of the tone correction factor $C(k_M)$ for the spectrum associated with $PNLTM$ is less than the average value of $C(k)$ for the five consecutive spectra (k_M-2) through (k_M+2), then the average value C_{avg} should be used to compute a bandsharing adjustment, Δ_B , and a value of $PNLTM$ adjusted for bandsharing.

$$C_{avg} = [C(k_M-2) + C(k_M-1) + C(k_M) + C(k_M+1) + C(k_M+2)] / 5$$

If $C_{avg} > C(k_M)$, then $\Delta_B = C_{avg} - C(k_M)$ and

$$PNLTM = PNLT(k_M) + \Delta_B$$

4.4.3 The value of $PNLTM$ adjusted for bandsharing shall be used for the calculation of EPNL.

4.5 Noise duration

4.5.1 The limits of the noise duration are bounded by the first and last 10 dB-down points. These shall be determined by examination of the $PNLT(k)$ time history with respect to $PNLTM$, as follows:

- a) the earliest value of $PNLT(k)$ which is greater than $PNLTM - 10$ dB is identified. This value and the value of $PNLT$ for the preceding point are compared. Whichever of these two points is associated with the value closest to $PNLTM - 10$ dB is identified as the first 10 dB-down point. The associated increment is designated as k_F ; and



- b) the last value of $PNLT(k)$ which is greater than $PNLTM - 10$ dB is identified. This value and the value of $PNLT$ for the following point are compared. Whichever of these two points is associated with the value closest to $PNLTM - 10$ dB is identified as the last 10 dB-down point. The associated increment is designated as k_L .

Note. - Figure A2-2 illustrates the selection of the first and last 10 dB-down points, k_F and k_L .

- 4.5.2 The noise duration in seconds should be equal to the number of $PNLT(k)$ values from k_F to k_L inclusive, times 0.5.
- 4.5.3 The value of $PNLTM$ used for determination of the 10 dB-down points shall include the adjustment for the presence of bandsharing, Δ_B , by the method of Section 4.4.2.

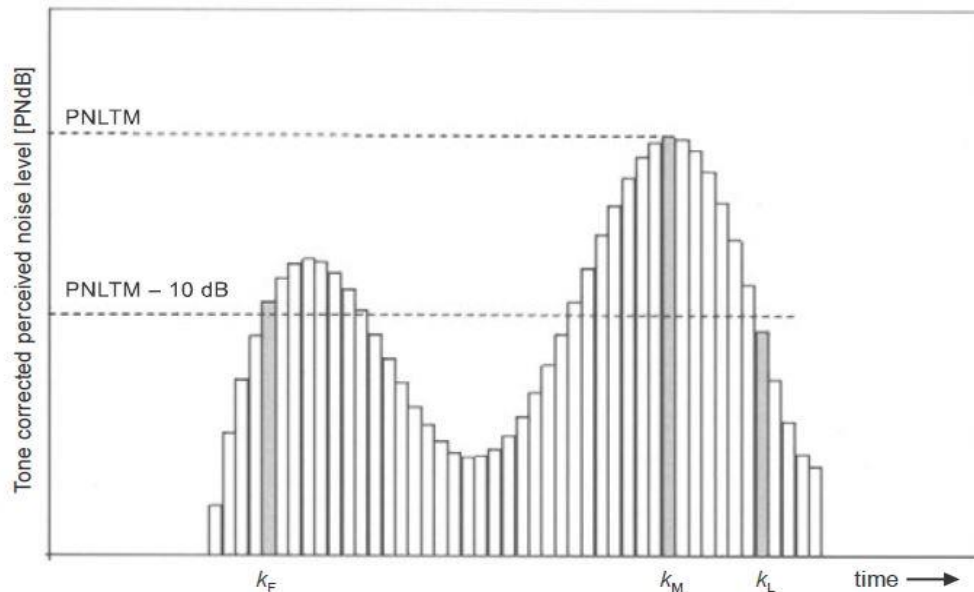


Figure A2-2. Example of a flyover noise time history

4.6 Effective perceived noise level

- 4.6.1 The effective perceived noise level, EPNL, is defined as the level, in EPNdB, of the time integral of $PNLT(t)$ over the noise event duration, normalized to a reference duration, T_0 , of 10 seconds. The noise event duration is bounded by t_1 , the time when $PNLT(t)$ is first equal to $PNLTM - 10$, and t_2 , the time when $PNLT(t)$ is last equal to $PNLTM - 10$.

In practice $PNLT$ is not expressed as a continuous function with time since it is computed from

discrete values of PNLT(k) every half second. In this case the basic working definition for EPNL is obtained with the following summation expression:

For $T_0 = 10$ and $\Delta t = 0.5$, this expression can be simplified as follows:

$$EPNL = 10 \log \sum_{k_F}^{k_L} 10^{0.1 \text{ PNLT}(k)} - 13$$

dB is a constant relating the one-half second values of PNLT(k) to the 10-second reference duration T_0 : $10 \log (0.5/10) = -13$.

Note. The time integral referred to in 4.6.1 is expressed as

4.6.2 The value of PNLT_M used for determination of EPNL shall include the adjustment for the presence of band sharing, Δ_B , by the method of Section 4.4.2.

4.7 Mathematical formulation of noy tables

Note. The relationship between sound pressure level (SPL) and the logarithm of perceived noisiness is illustrated in Table A2-3 and Figure A2-3. The important aspects of the mathematical formulation are:

- a) the slopes $M(b)$, $M(c)$, $M(d)$ and $M(e)$ of the straight lines;
- b) the intercepts $SPL(b)$ and $SPL(c)$ of the lines on the SPL axis; and
- c) the coordinates of the discontinuities, $SPL(a)$ and $\log n(a)$; $SPL(d)$ and $\log n = -1.0$; and $SPL(e)$ and $\log n = \log (0.3)$.

4.7.1 The perceived noisiness value n shall be calculated from an instantaneous one-third octave band sound pressure level at a frequency band i , $SPL(i)$, as follows:

- a) If $SPL(i) \geq SPL(a)$
 $n = \text{antilog} \{M(c) [SPL(i) - SPL(c)]\}$
- b) If $SPL(b) \leq SPL(i) < SPL(a)$
 $n = \text{antilog} \{M(b) [SPL(i) - SPL(b)]\}$
- c) If $SPL(e) \leq SPL(i) < SPL(b)$
 $n = 0.3 \text{ antilog} \{M(e) [SPL(i) - SPL(e)]\}$
- d) If $SPL(d) \leq SPL(i) < SPL(e)$
 $n = 0.1 \text{ antilog} \{M(d) [SPL(i) - SPL(d)]\}$

where $SPL(a)$, $SPL(b)$, $SPL(c)$, $SPL(d)$, $SPL(e)$, $M(b)$, $M(c)$, $M(d)$ and $M(e)$ are provided in Table A2-3 as a function of the SPL frequency band i

REPORTING OF DATA TO THE CERTIFICATING AUTHORITY

5.1 General

- 5.1.1 Data representing physical measurements or corrections to measured data should be recorded in permanent form and appended to the record.
- 5.1.2 All corrections should be approved by the certificating authority. In particular the corrections to measurements for equipment response deviations should be reported.
- 5.1.3 Estimates of the individual errors inherent in each of the operations employed in obtaining the final data should be reported, if required.



Table A2-3. Constants for mathematically formulated noy values

BAND (i)	ISO BAND	f Hz	SPL(a)	SPL(b)	SPL(c)	SPL(d)	SPL(e)	M(b)	M(c)	M(d)	M(e)
1	17	50	91.0	64	52	49	55	0.043478	0.030103	0.079520	0.058098
2	18	63	85.9	60	51	44	51	0.040570	0.030103	0.068160	0.058098
3	19	80	87.3	56	49	39	46	0.036831	0.030103	0.068160	0.052288
4	20	100	79.9	53	47	34	42	0.036831	0.030103	0.059640	0.047534
5	21	125	79.8	51	46	30	39	0.035336	0.030103	0.053013	0.043573
6	22	160	76.0	48	45	27	36	0.033333	0.030103	0.053013	0.043573
7	23	200	74.0	46	43	24	33	0.033333	0.030103	0.053013	0.040221
8	24	250	74.9	44	42	21	30	0.032051	0.030103	0.053013	0.037349
9	25	315	94.6	42	41	18	27	0.030675	0.030103	0.053013	0.034859
10	26	400	∞	40	40	16	25	0.030103		0.053013	0.034859
11	27	500	∞	40	40	16	25	0.030103		0.053013	0.034859
12	28	630	∞	40	40	16	25	0.030103		0.053013	0.034859
13	29	800	∞	40	40	16	25	0.030103		0.053013	0.034859
14	30	1 000	∞	40	40	16	25	0.030103		0.053013	0.034859
15	31	1 250	∞	38	38	15	23	0.030103		0.059640	0.034859
16	32	1 600	∞	34	34	12	21	0.029960		0.053013	0.040221
17	33	2 000	∞	32	32	9	18	0.029960		0.053013	0.037349
18	34	2 500	∞	30	30	5	15	0.029960		0.047712	0.034859
19	35	3 150	∞	29	29	4	14	0.029960		0.047712	0.034859
20	36	4 000	∞	29	29	5	14	0.029960		0.053013	0.034859
21	37	5 000	∞	30	30	6	15	0.029960		0.053013	0.034859
22	38	6 300	∞	31	31	10	17	0.029960	0.029960	0.068160	0.037349
23	39	8 000	44.3	37	34	17	23	0.042285	0.029960	0.079520	0.037349
24	40	10 000	50.7	41	37	21	29	0.042285	0.029960	0.059640	0.043573

NOT APPLICABLE

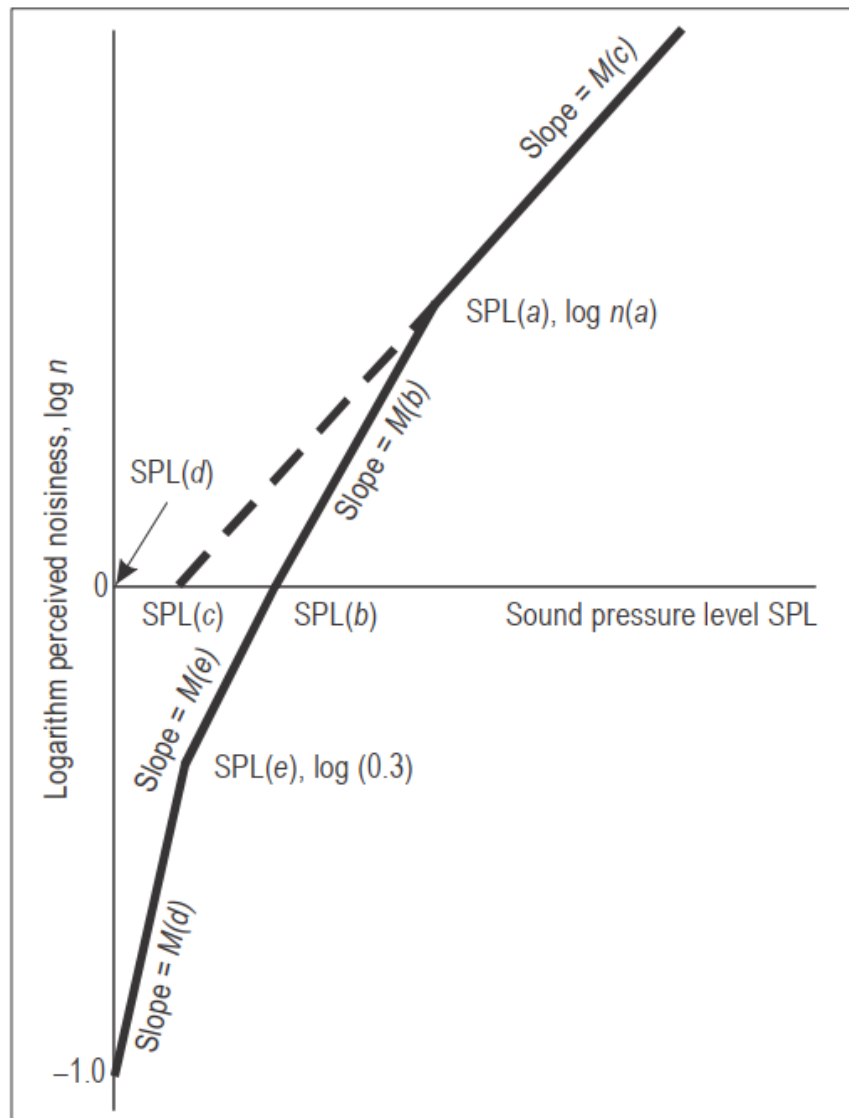


Figure A2-3. Perceived noisiness as a function of sound pressure level

5.2 Data reporting

- 5.2.1 Measured and corrected sound pressure levels should be presented in one-third octave band levels obtained with equipment conforming to the Standards described in Section 3 of this appendix.
- 5.2.2 The type of equipment used for measurement and analysis of all acoustic performance and meteorological data should be reported.
- 5.2.3 The following atmospheric environmental data, measured immediately before, after, or during each test at the observation points prescribed in Section 2 of this appendix

should be reported:


- a) air temperature and relative humidity;
- b) wind speeds and wind directions; and
- c) atmospheric pressure.

5.2.4 Comments on local topography, ground cover, and events that might interfere with sound recordings should be reported.

5.2.5 The following information should be reported:

- a) type, model and serial numbers (if any) of aircraft, engines, propellers or rotors (as applicable);
- b) gross dimensions of aircraft and location of engines and rotors (if applicable);
- c) aircraft gross mass for each test run and center of gravity range for each series of test runs;
- d) aircraft configuration such as flap, air brakes and landing gear positions and propeller pitch angles (if applicable);
- e) whether auxiliary power units (APU), when fitted, are operating;
- f) conditions of pneumatic engine bleeds and engine power take-offs;
- g) indicated airspeed in kilometres per hour (knots);
- h)
 - 1) *for jet aeroplanes*: engine performance in terms of net thrust, engine pressure ratios, jet exhaust temperatures and fan or compressor shaft rotational speeds as determined from aeroplane instruments and manufacturer’s data;
 - 2) *for propeller-driven aeroplanes*: engine performance in terms of brake horsepower and residual thrust or equivalent shaft horsepower or engine torque and propeller rotational speed as determined from aeroplane instruments and manufacturer’s data;
 - 3) *for helicopters*: engine performance and rotor speed in rpm during each demonstration;
- i) aircraft flight path and ground speed during each demonstration; and
- j) any aircraft modifications or non-standard equipment likely to affect the noise characteristics of the aircraft and approved by the certifying authority.

5.3 Reporting of noise certification reference conditions

<i>Kuwait Civil Aviation Safety Regulations</i>		<i>KCASR 16 – Environmental Protection</i>
		<i>Volume - I</i>

Aircraft position and performance data and the noise measurements should be corrected to the noise certification reference conditions as specified in the relevant chapter of Part II, and these conditions, including reference parameters, procedures and configurations should be reported.

5.4 Validity of results

5.4.1 Three average reference EPNL values and their 90 per cent confidence limits should be produced from the test results and reported, each such value being the arithmetical average of the adjusted acoustical measurements for all valid test runs at the appropriate measurement point (take-off, approach, or lateral or overflight, in the case of helicopters). If more than one acoustic measurement system is used at any single measurement location, the resulting data for that measurement location shall be averaged as a single measurement for each test run.

5.4.2 For helicopters, the three microphone test results for each flight shall be averaged as a single measurement. The calculation should be performed by:

- a) computing the arithmetic average for each flight phase using the values from each reference microphone point;
- b) computing the overall arithmetic average for each appropriate reference condition (take-off, overflight or approach) using the values in a) and the related 90 per cent confidence limits.

5.4.3 For helicopters, a flight shall only be considered valid if simultaneous measurements are made at all three noise measurement locations.

5.4.4 The minimum sample size acceptable for each of the three certification measuring points for aeroplanes and for each set of three microphones for helicopters is six. The samples should be large enough to establish statistically for each of the three average noise certification levels a 90 per cent confidence limit not exceeding ± 1.5 EPNdB. No test result should be omitted from the averaging process unless otherwise specified by the certifying authority.

Note.- Methods for calculating the 90 per cent confidence interval are given in the section of the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft, concerning the calculation of confidence intervals.

5.4.3 The average EPNL figures obtained by the foregoing process should be those by which the noise performance of the aircraft is assessed against the noise certification criteria.

6. RESERVED



7.

7. SOUND ATTENUATION IN AIR

7.1 The atmospheric attenuation of sound should be determined by the following equations:

$$\alpha(i) = 10^{[2.05 \log(f_o/1\ 000) + 1.1394 \times 10^{-3}\theta T - 1.916984]} + \eta(\delta) \times 10^{[\log(f_o) + 8.42994 \times 10^{-3}\theta T - 2.755624]}$$

$$\delta = \sqrt{\frac{1010}{f_o}} 10^{(\log RH - 1.328924 + 3.179768 \times 10^{-2} \times T)} \times 10^{(-2.173716 \times 10^{-4} \times T^2 + 1.7496 \times 10^{-6} \times T^3)}$$

where:

- * Gear up, speed of at least V₂ + 19 km/h (V₂ + 10 kt), take-off thrust.
- ** Gear up, speed of at least V₂ + 19 km/h (V₂ + 10 kt), after cutback.

$\eta(\delta)$ is given by Table A2-4 and f_o by Table A2-5;

$\alpha(i)$ being the attenuation coefficient in dB/100 m;

θ being the temperature in °C; and

H being the relative humidity expressed as a percentage.

Table A2-4. Values of $\eta(\delta)$

δ	$\eta(\delta)$	δ	$\eta(\delta)$
0.00	0.000	2.50	0.450
0.25	0.315	2.80	0.400
0.50	0.700	3.00	0.370
0.60	0.840	3.30	0.330
0.70	0.930	3.60	0.300
0.80	0.975	4.15	0.260
0.90	0.996	4.45	0.245
1.00	1.000	4.80	0.230
1.10	0.970	5.25	0.220
1.20	0.900	5.70	0.210
1.30	0.840	6.05	0.205
1.50	0.750	6.50	0.200
1.70	0.670	7.00	0.200
2.00	0.570	10.00	0.200
2.30	0.495		

A term of quadratic interpolation shall be used where necessary.

Table A2-5. Value of f_o

Centre frequency of the 1/3 octave band (Hz)	f_o (Hz)	Centre frequency of the 1/3 octave band (Hz)	f_o (Hz)
50	50	800	800
63	63	1 000	1 000
80	80	1 250	1 250
100	100	1 600	1 600
125	125	2 000	2 000
160	160	2 500	2 500
200	200	3 150	3 150
250	250	4 000	4 000
315	315	5 000	4 500
400	400	6 300	5 600
500	500	8 000	7 100
630	630	10 000	9 000

8. ADJUSTMENT OF AIRCRAFT FLIGHT TEST RESULTS

8.1 Flight profiles and noise geometry

Note 1: Flight profiles for both test and reference conditions are described by their geometry relative to the ground, the associated aircraft ground speed, and, in the case of aeroplanes, the associated engine control parameter(s) used for determining the acoustic emission of the aeroplane. Idealized aircraft flight profiles are described in 8.1.1 for aeroplanes and 8.1.2 for helicopters.

Note 2. The “noise flight path” referred to in 8.1.1 and 8.1.2 is defined in accordance with the requirements of 2.3.2.

8.1.1 Aeroplane flight profiles

8.1.1.1 Reference lateral full-power profile characteristics

The profile characteristics for the aeroplane take-off procedure for noise measurements made at the lateral full-power noise measurement points illustrated in Figure A2-4, shall be defined as follows:

- a) the aeroplane begins the take-off roll at point A and lifts off at point B at full take-off power. The climb angle increases between points B and C. From point C the climb angle is constant up to point F, the end of the noise flight path; and
- b) positions K_{2L} and K_{2R} are the left and right lateral noise measurement points for jet aeroplanes, located on a line parallel to and at the specified distance from the runway center line, where the noise level during take-off is greatest. Position K₄ is the “lateral” full-power noise measurement point for propeller-driven aeroplanes located on
- c) the extended center line of the runway vertically below the point on the climb-out flight path where the aeroplane is at the specified height.

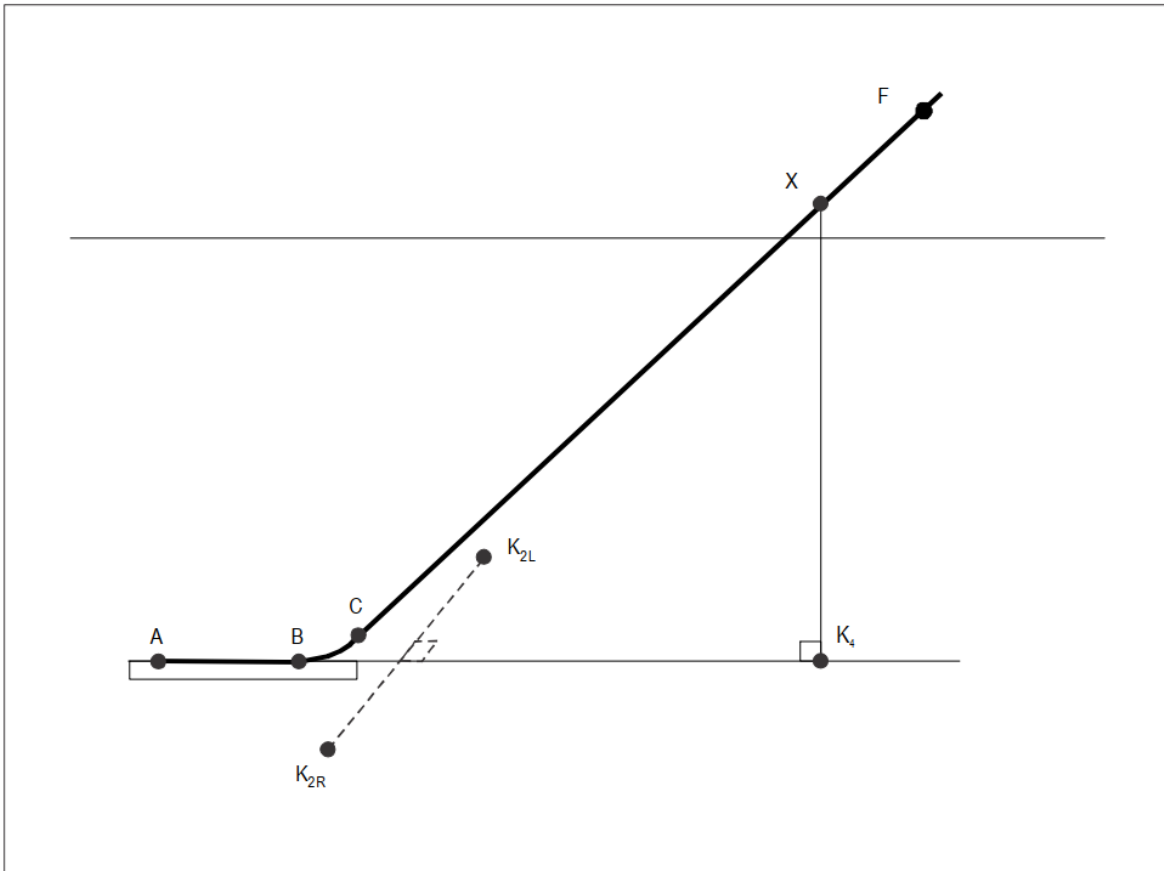


Figure A2-4. Reference aeroplane lateral full-power profile characteristics

8.1.1.2 Reference flyover profile characteristics

The profile characteristics for the aeroplane take-off procedure for noise measurements made at the flyover noise measurement point, illustrated in Figure A2-5, shall be defined as follows:

- a) the aeroplane begins the take-off roll at point A and lifts off at point B at full take-off power. The climb angle increases between points B and C. From point C the climb angle is constant up to point D where thrust (or power) reduction is initiated. At point E the thrust (or power) and climb angle are once more stabilized and the aeroplane continues to climb at a constant angle up to point F, the end of the noise flight path; and

Note.- The flyover profile may be flown without thrust (power) reduction in which case point C will extend through point D at a constant climb angle.

- b) position K_1 is the flyover noise measurement point and AK_1 is the specified distance from start of roll to the flyover noise measuring point.

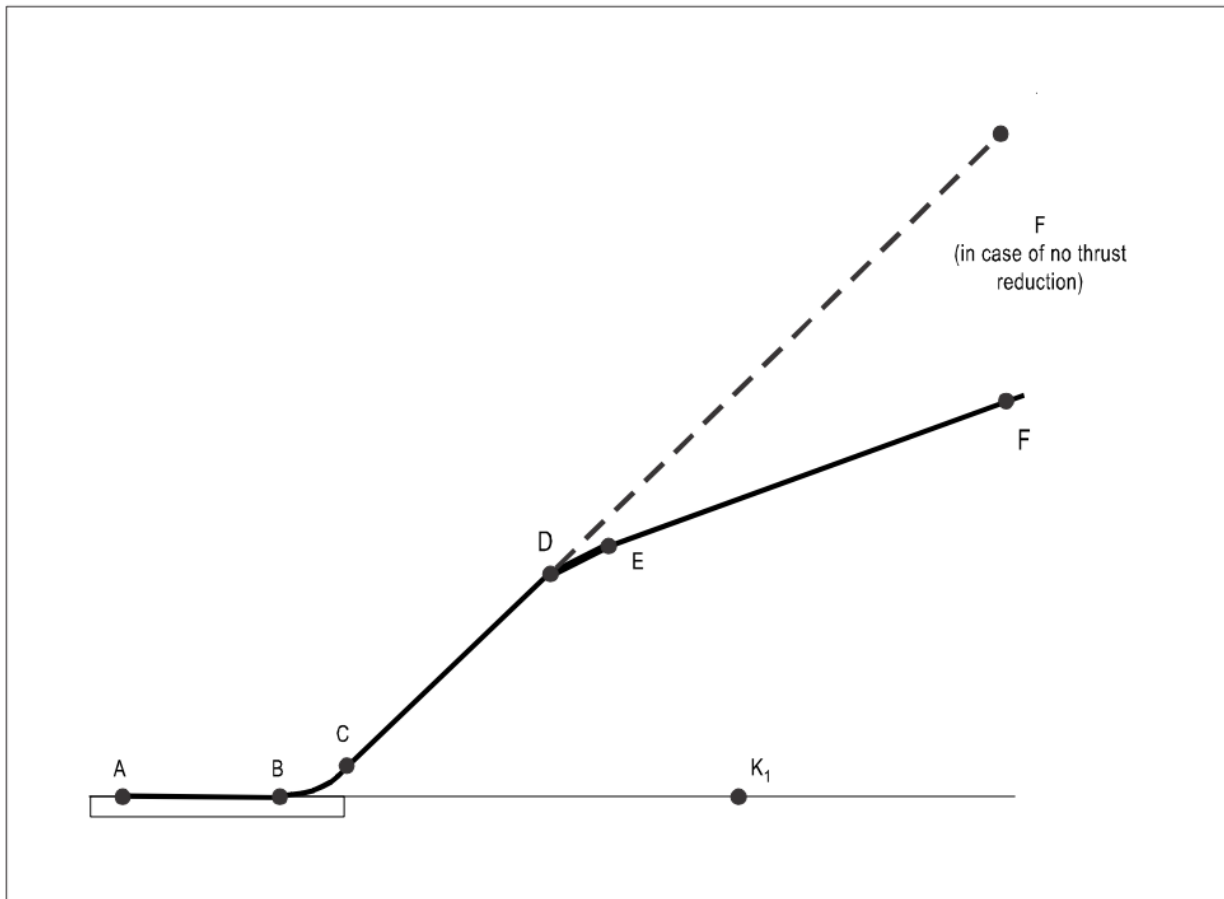


Figure A2-5. Reference aeroplane flyover profile characteristics

8.1.1.3 Reference approach profile characteristics

The profile characteristics for the aeroplane approach procedure for noise measurements made at the approach noise measurement point, illustrated in Figure A2-6, shall be defined as follows::

- the aeroplane is initially stabilized on the specified glideslope at point G and continues through point H and point I, touching down on the runway at point J; and
- position K_3 is the approach noise measurement point and K_3O is the specified distance from the approach noise measurement point to the runway threshold.
- The aeroplane reference point during approach measurements may be the ILS antenna.

8.1.2 Helicopter flight profiles

8.1.2.1 Reference take-off profile characteristics

The profile characteristics for the helicopter take-off procedure for noise measurements made at the take-off noise measurement point, illustrated in Figure A2-7, shall be defined as follows :

- a) The helicopter is initially stabilized in level flight at point A at the best rate of climb speed V_y . The helicopter continues to point B where take-off power is applied, and a steady climb is initiated. A steady climb is maintained through point X and beyond to point F, the end of the noise flight path; and
- b) Position K_1 is the take-off noise measurement point, and NK_1 is the specified distance from the initiation of the steady climb to the take-off reference noise measurement point. Positions K_1' and K_1'' are associated noise measurement points located on a line $K_1'K_1''$ through K_1 at right angles to the take-off flight track TM and at the specified distance either side of K_1 .

Note.- In practice the point at which take-off power is applied will be some distance before point B to provide sufficient time to transition to the climb condition.

8.1.2.2 Reference overflight profile characteristics

Figure A2-8 illustrates the profile characteristics for the helicopter overflight procedure for noise measurements made at the overflight noise measurement points, illustrated in Figure A2-8, shall be defined as follows:

- a) The helicopter is stabilized in level flight at point D and flies through point W, overhead the overflight noise measurement point K_2 , to point E, the end of the noise flight path; and
- b) Position K_2 is the overflight noise measurement point, and K_2W is the specified height of the helicopter overhead the overflight noise measurement point. Positions K_2' and K_2'' are associated noise measurement points located on a line $K_2'K_2''$ through K_2 at right angles to the overflight flight track RS and at the specified distance either side of K_2 .

8.1.2.3 Reference approach profile characteristics

The profile characteristics for the helicopter approach procedure for noise measurements made at the approach noise measurement points, illustrated in Figure A2-9, shall be defined as follows:

- a) the helicopter is initially stabilized on the specified glideslope at point G and continues through point H and point I, touching down at point J; and
- b) position K_3 is the approach noise measurement point, and K_3H is the specified height of the helicopter overhead the approach noise measurement point.



Positions K3' and K3'' are associated noise measurement points located on a line K3'K3'' at right angles to the approach flight track PU and at the specified distance either side of K3.

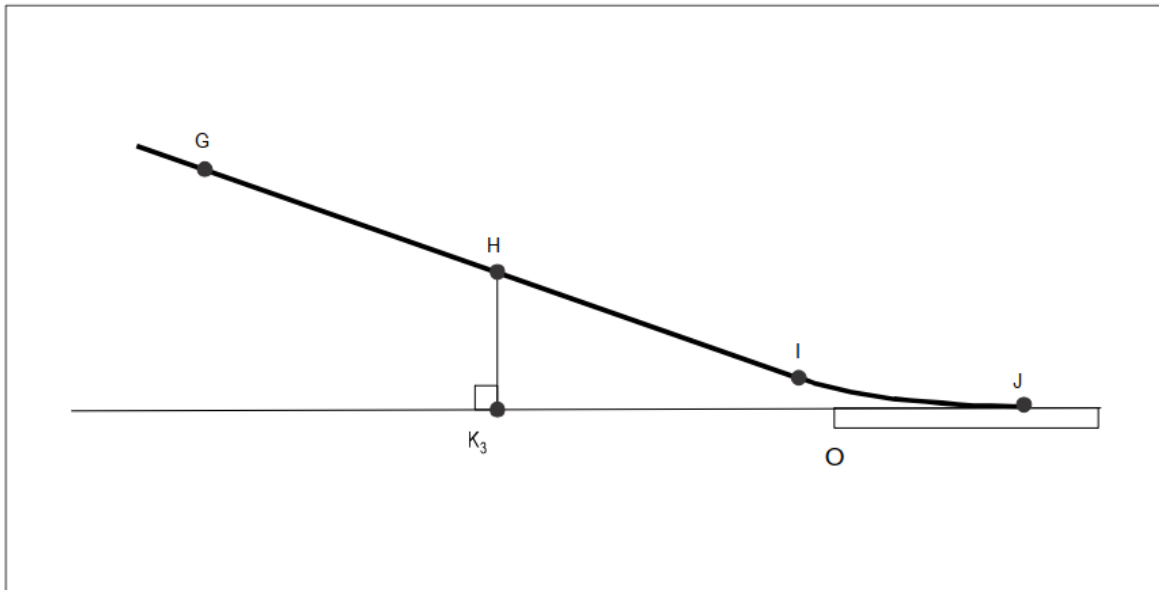


Figure A2-6. Reference aeroplane approach profile characteristics

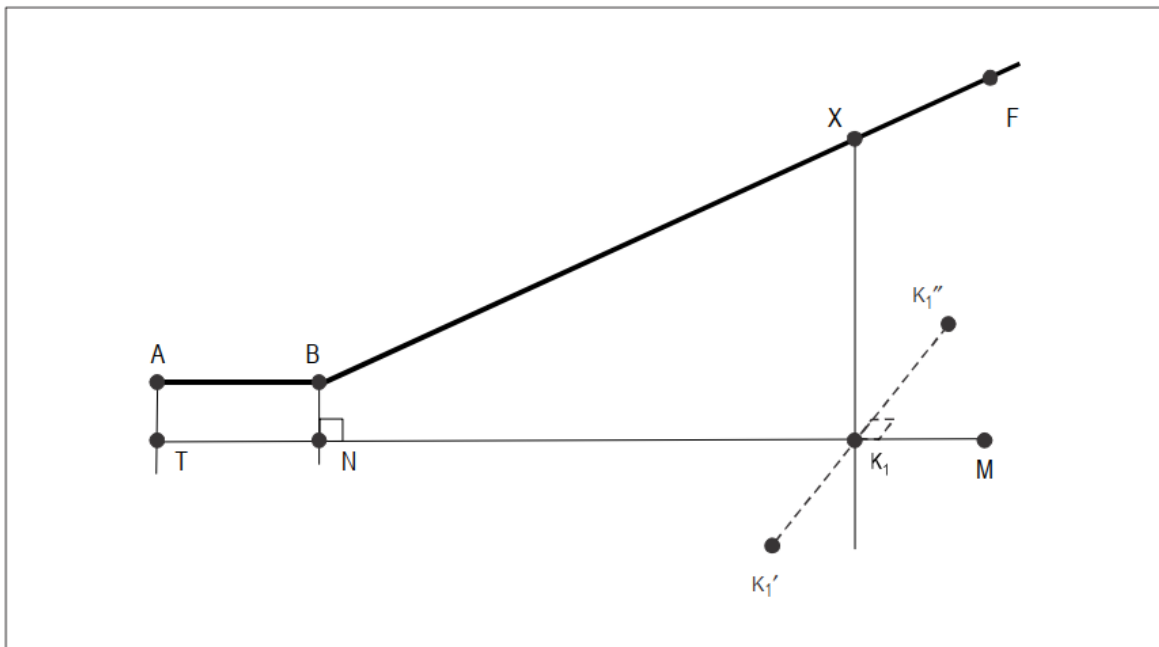


Figure A2-7. Reference helicopter take-off profile characteristics

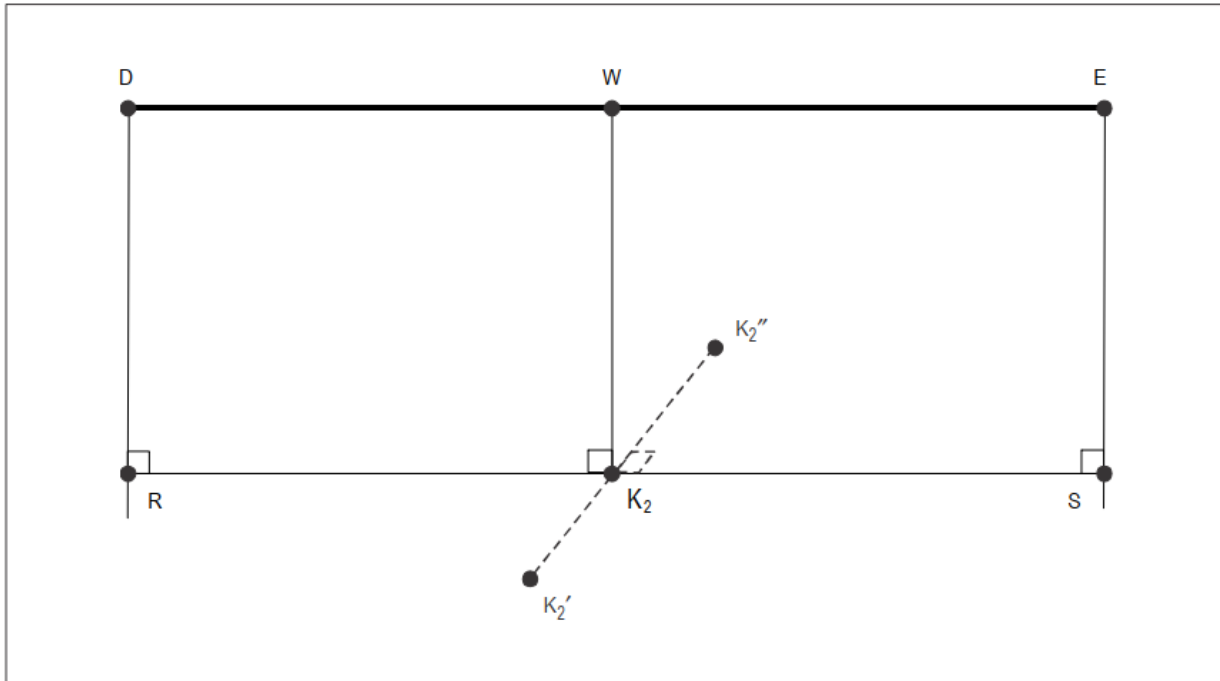


Figure A2-8. Reference helicopter overflight profile characteristics

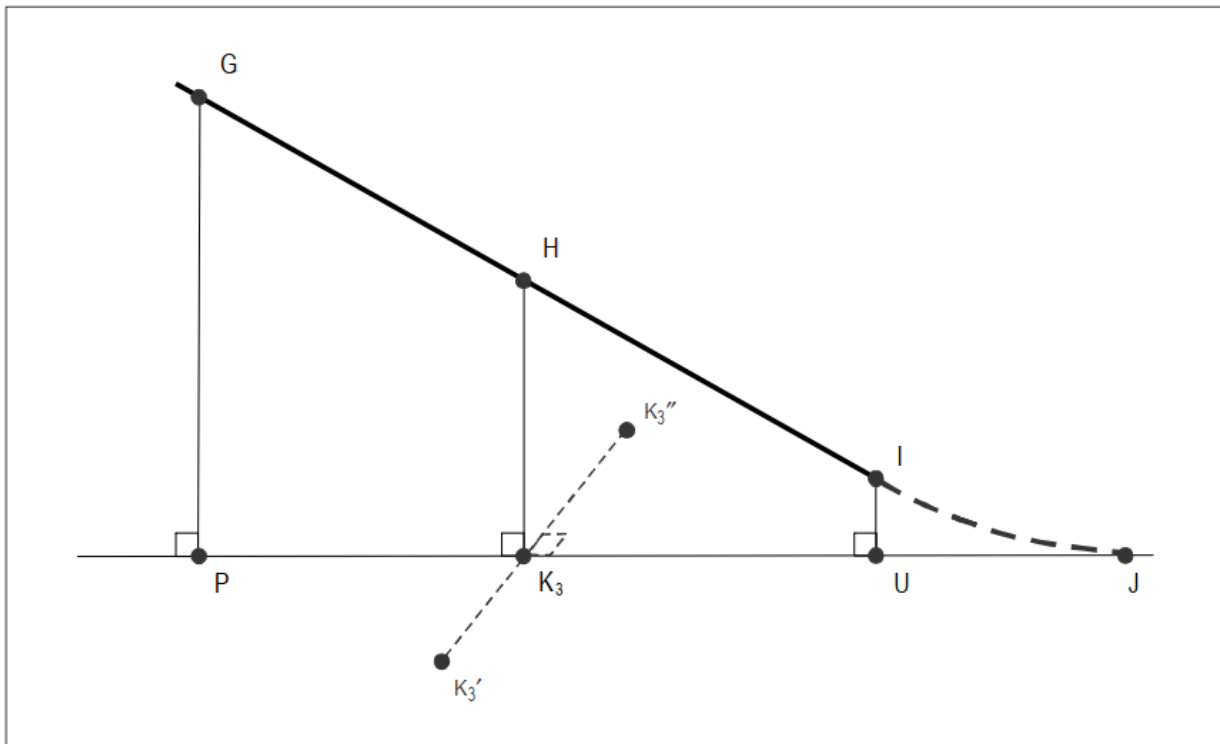


Figure A2-9. Reference helicopter approach profile characteristics

~~position K_3 is the approach noise measurement point, and K_3H is the specified height of the helicopter overhead the approach noise measurement point. Positions K_3' and K_3'' are associated noise measurement points located on a line $K_3'K_3''$ at right angles to the approach flight track PU and at the specified distance either side of K_3 .~~

8.1.3 Adjustment of measured noise levels from measured to reference profile in the calculation of EPNL

Note.- The “useful portion of the measured flight path” referred to in this section is defined in accordance with the requirements of 2.3.2.

8.1.3.1 For the case of a microphone located beneath the flight path, the portions of the test flight path and the reference flight path which are significant for the adjustment of the measured noise levels from the measured profile to the reference profile in the EPNL calculation shall be defined as illustrated in Figure A2-10, where:

- a) XY represents the useful portion of the measured flight path (Figure A2-10 a)), and X_rY_r that of the corresponding reference flight path (Figure A2-10 b)); and
- b) K is the actual noise measurement point and K_r the reference noise measurement point. Q represents the aircraft position on the measured flight path at which the noise was emitted and observed as PNLTM at point K. The angle between QK and the direction of flight along the measured flight path is θ , the acoustic emission angle. Q_r is the corresponding position on the reference flight path where the angle between Q_rK_r is also θ . QK and Q_rK_r are, respectively, the measured and reference noise propagation paths.

Note.— This situation will apply in the case of aeroplanes for the flyover, approach, and for propeller-driven aeroplanes only, the lateral full-power noise measurements, and in the case of helicopters for the take-off, overflight, and approach noise measurements for the center microphone only.

8.1.3.2 For the case of a microphone laterally displaced to the side of the flight path, the portions of the test flight path and the reference flight path which are significant for the adjustment of the measured noise levels from the measured profile to the reference profile in the EPNL calculation shall be defined as illustrated in Figure A2-11, where:

- a) XY represents the useful portion of the measured flight path (Figure A2-11 a)), and X_rY_r that of the corresponding reference flight path (Figure A2-11 b)); and
- b) K is the actual noise measurement point and K_r the reference noise measurement point. Q represents the aircraft position on the measured flight path at which the noise was emitted and observed as PNLTM at point K. The angle between QK and the direction of flight along the measured flight path is θ , the acoustic emission

angle. The angle between QK and the ground is ψ , the elevation angle. Q_r is the corresponding position on the reference flight path where the angle between Q_rK_r and the direction of flight along the reference flight path is also θ , and the angle between Q_rK_r and the ground is ψ_r , where in the case of aeroplanes, the difference between ψ and ψ_r is minimized.

Note. - This situation will apply in the case of jet aeroplanes for the lateral full-power noise measurements, and in the case of helicopters for the take-off, overflight and approach noise measurements for the two laterally displaced microphones only.

8.1.3.3 In both situations the acoustic emission angle θ should be established using three-dimensional geometry.

Note 1. In the case of lateral full-power noise measurements of jet aeroplanes the extent to which differences between ψ and ψ_r can be minimized is dependent on the geometrical restrictions imposed by the need to maintain the reference microphone on a line parallel to the extended runway center line.

Note 2 .- In the case of helicopter measurements, there is no requirement to minimize the difference between ψ and ψ_r . However, these angles should be determined and reported.

8.1.3.4 The reference ground track is defined as the vertical projection of the reference flight path onto the ground

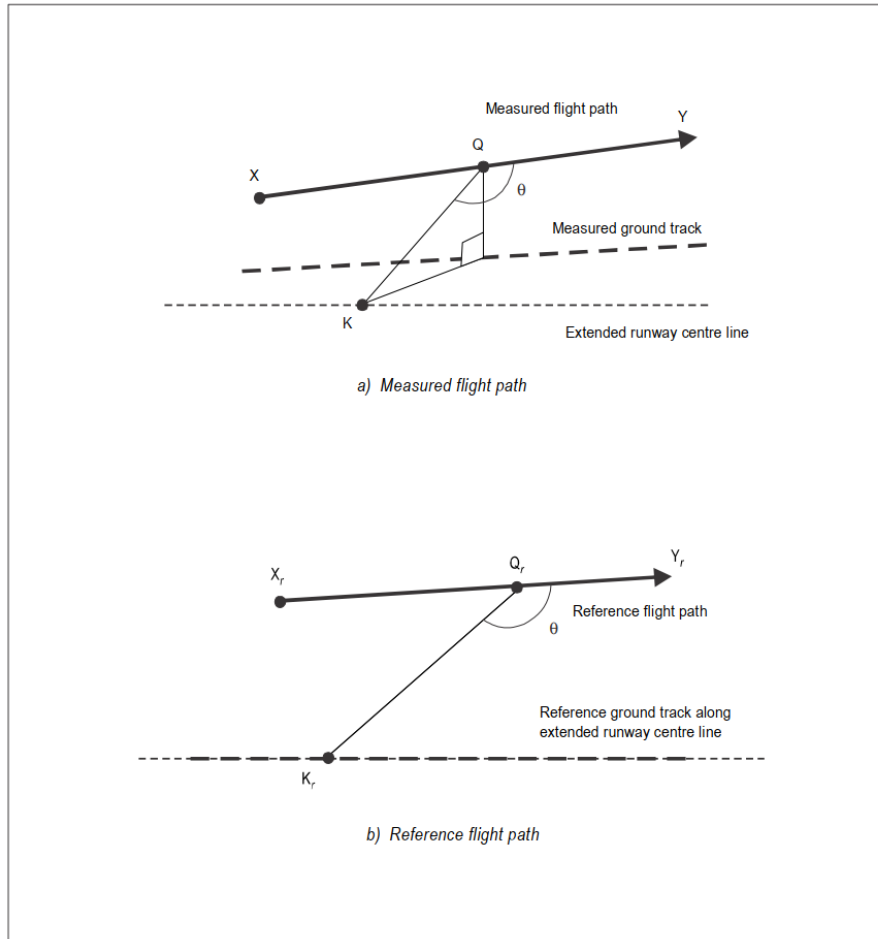


Figure A2-10. Profile characteristics influencing noise level for microphone located beneath the flight path

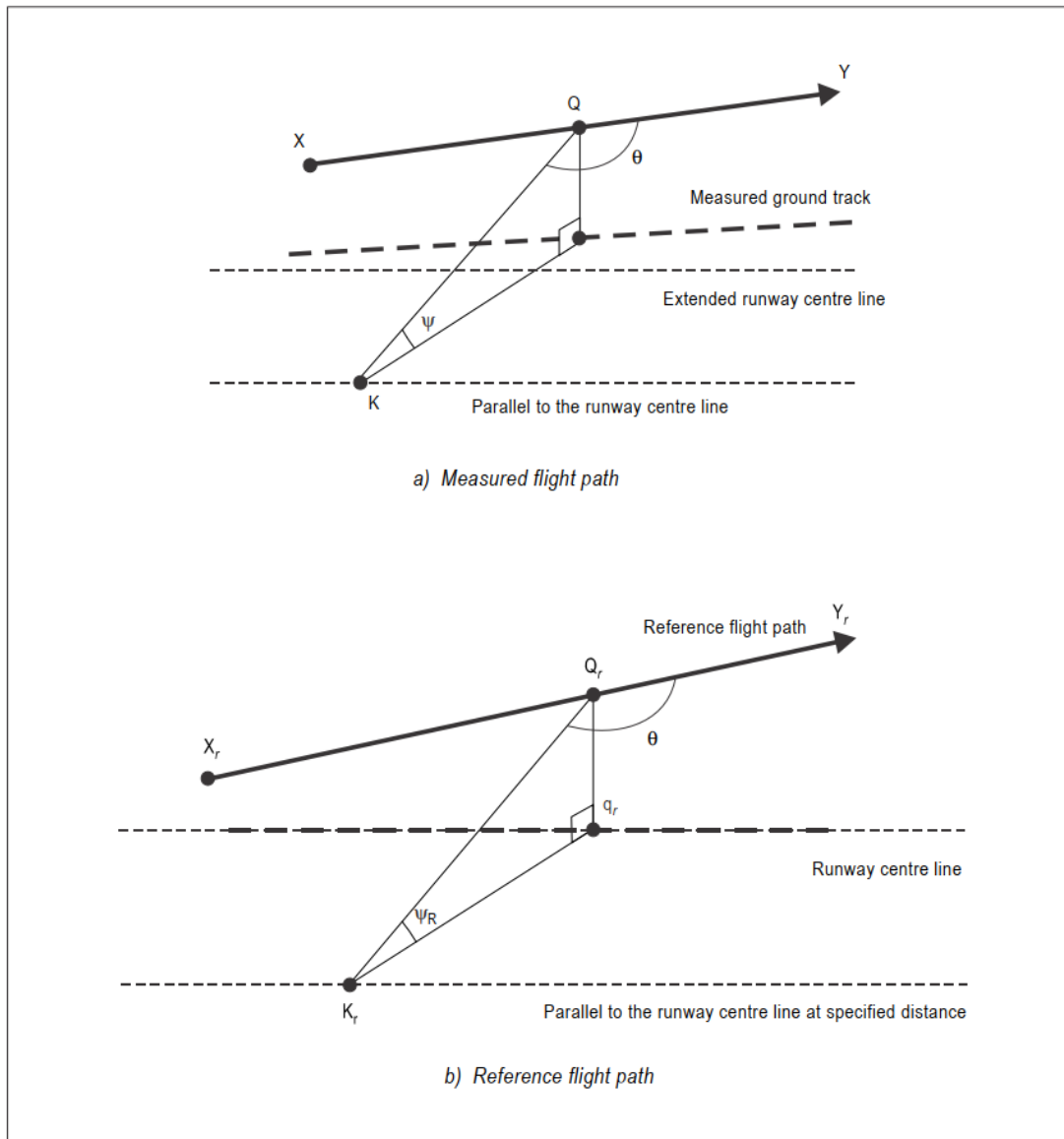



Figure A2-11. Profile characteristics influencing noise level for laterally displaced microphone

8.2 Selection of adjustment method

8.2.1 Adjustments to the measured noise values should be made for the following: a) aircraft flight path and velocity relative to the microphone; b) sound attenuation in air; and c) source noise.

8.2.2 For helicopters, the simplified method described in 8.3 should be used.

Note. - The integrated method may be approved by the certificating authority as being equivalent to the simplified method.

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8.2.3 For aeroplanes, either the simplified method, described in 8.3, or the integrated method, described in 8.4, should be used for the lateral, flyover or approach conditions. The integrated method should be used when:

- a) for flyover, the absolute value of the difference between the value of $EPNL_r$, when calculated according to the simplified method described in 8.3, and the measured value of EPNL calculated according to the procedure described in 4.1.3 is greater than 8 EPNdB;
- b) for approach, the absolute value of the difference between the value of $EPNL_r$, when calculated according to the simplified method described in 8.3, and the measured value of EPNL calculated according to the procedure described in 4.1.3 is greater than 4 EPNdB; or
- c) for flyover or approach, the value of $EPNL_r$, when calculated according to the simplified method described in 8.3, is greater than the maximum noise levels prescribed in 3.4 of Part II, Chapter 3, less 1 EPNdB.

Note.- Part II, Chapter 3, 3.7.6, specifies limitations regarding the validity of test data based upon both the extent to which $EPNL_r$ differs from EPNL, and also the proximity of the final $EPNL_r$ values to the maximum permitted noise levels, regardless of the method used for adjustment.

8.3 Simplified method of adjustment

8.3.1 General

8.3.1.1 The simplified adjustment method shall consist of the determination and application of adjustments to the EPNL calculated from the measured data for the differences between measured and reference conditions at the moment of PNLTM. The adjustment terms are:

- a) Δ_1 — adjustment for differences in the PNLTM spectrum under test and reference conditions (see 8.3.2);
- b) Δ_{Peak} — adjustment for when the PNL for a secondary peak, identified in the calculation of EPNL from measured data and adjusted to reference conditions, is greater than the PNL for the adjusted PNLTM spectrum (see 8.3.3);
- c) Δ_2 — adjustment for the difference in noise duration, taking into account the differences between test and reference aircraft speed and position relative to the microphone (see 8.3.4); and
- d) Δ_3 — adjustment for differences in source noise generating mechanisms (see 8.3.5).

8.3.1.2 The coordinates (time, X, Y and Z) of the reference data point associated with the

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emission of PNL_{TM,r} should be determined such that the acoustic emission angle θ on the reference flight path, relative to the reference microphone, is the same value as the acoustic emission angle of the as-measured data point associated with PNL_{TM}.

8.3.1.3 The adjustment terms described in 8.3.2 to 8.3.5 shall be applied to the EPNL calculated from measured data to obtain the simplified reference condition effective perceived noise level, EPNL_r as described in 8.3.6.

8.3.1.4 Any asymmetry in the lateral noise should be accounted for in the determination of EPNL as described in 8.3.7.

8.3.2 Adjustments to spectrum at PNL_{TM}

8.3.2.1 The one-third octave band levels SPL(*i*) used to construct PNL(*k_M*) (the PNL at the moment of PNL_{TM} observed at measurement point K) should be adjusted to reference levels SPL_r(*i*) as follows:

$$\begin{aligned} \text{SPL}_{r}(i) = & \text{SPL}(i) + \Delta A(i) \\ & - \Delta AR(i) \\ & + 20 * \log[QK/Q_rK_r] \end{aligned}$$

In this expression:

- the term SPL_r(*i*) is the computed reference condition sound pressure level for one third octave band *i* at the moment of PNL_{TM};
- the term SPL(*i*) is the test-day sound pressure level for one third octave band *i* at the moment of PNL_{TM};
- the term $\Delta A(i)$ is the total test-day atmospheric absorption adjustment in dB for band *i* at the moment of PNL_{TM} for test day sound propagation distance QK;
- the term $\Delta AR(i)$ is the total reference condition atmospheric absorption adjustment in dB for band *i* at the moment of PNL_{TM} for reference sound propagation distance Q_rK_r;
- the term $20 \log (QK/Q_rK_r)$ accounts for the effect of the change in the sound propagation path length due to spherical spreading (also known as the “inverse square” law);
- QK and Q_rK_r are distances in metres, and $\alpha(i)$.

Note-Refer to Figures A2-10 and A2-11 for identification of positions and distances referred to in this paragraph.

8.3.2.2 The adjusted values of SPL_r(*i*) obtained in 8.3.2.1 should be used to calculate a reference

condition PNL_T value, PNL_T(k_M), as described in 4.2 and 4.3 of this appendix. The value of the bandsharing adjustment, Δ_B, calculated for the test-day PNL_TM by the method of 4.4.2, should be added to this PNL_T(k_M) value to obtain the reference condition PNL_TM_r:

$$\text{PNLTM}_r = \text{PNLT}_r(k_M) + \Delta_B$$

An adjustment term, Δ₁, is then calculated as follows:

$$\Delta_1 = \text{PNLTM}_r - \text{PNLTM}$$

8.3.2.3 Δ₁ should be added algebraically to the EPNL calculated from measured data as described in 8.3.6.

8.3.3 Adjustment for secondary peaks

8.3.3.1 During a test flight any values of PNL_T that are within 2 dB of PNL_TM are defined as “secondary peaks”. The one-third octave band levels for each “secondary peak” should be adjusted to reference conditions according to the procedure defined in 8.3.2.1. Adjusted values of PNL_T_r should be calculated for each “secondary peak” as described in 4.2 and 4.3 of this appendix. If any adjusted peak value of PNL_T_r exceeds the value of PNL_TM_r, a Δ_{Peak} adjustment should be applied.

8.3.3.2 Δ_{Peak} should be calculated as follows:

$$\Delta_{\text{Peak}} = \text{PNLT}_r(\text{MaxPeak}) - \text{PNLTM}_r$$

where PNL_T_r(MaxPeak) is the reference condition PNL_T value of the largest of the secondary peaks; and PNL_TM_r is the reference condition PNL_T value at the moment of PNL_TM.

8.3.3.3 Δ_{Peak} should be added algebraically to the EPNL calculated from measured data as described in 8.3.6.

8.3.4 Adjustment for effects on noise duration

8.3.4.1 Whenever the measured flight paths and/or the ground velocities of the test conditions differ from the reference flight paths and/or the reference ground velocities, adjustments to noise duration should be determined as follows.

8.3.4.2 Referring to the flight paths shown in Figures A2-10 and A2-11, the adjustment term ₂ should be calculated from the measured data as follows:

$$_2 = -7.5 \log (QK/Q_rK_r) + 10 \log (V_G/V_{Gr})$$

where:

V_G is the test ground speed (horizontal component of the test airspeed); and

V_{Gr} is the reference ground speed (horizontal component of the reference airspeed).

Note.- The factors, -7.5 and 10 , have been determined empirically from a representative sample population of certificated aeroplanes and helicopters. The factors account for the effects of changes in noise duration on EPNL due to distance and speed, respectively.

8.3.4.3 Δ_2 should be added algebraically to the EPNL calculated from measured data as described in 8.3.6.

8.3.5 Source noise adjustments

8.3.5.1 The source noise adjustment should be applied to take account of differences in test and reference source noise generating mechanisms. For this purpose the effect on aircraft propulsion source noise of differences between the acoustically significant propulsion operating parameters actually realized in the certification flight tests and those calculated or specified for the reference conditions of Chapter 3, 3.6.1.5, is determined. Such operating parameters may include for jet aeroplanes, the engine control parameter μ (typically normalized low pressure fan speed, normalized engine thrust or engine pressure ratio), for propeller-driven aeroplanes both shaft horsepower and propeller helical tip Mach number and for helicopters, during overflight only, advancing rotor blade tip Mach number. The adjustment should be determined from manufacturer's data approved by the certifying authority.

8.3.5.2 For aeroplanes, the adjustment term Δ_3 should normally be determined from sensitivity curve(s) of EPNL versus the propulsion operating parameter(s) referred to in 8.3.5.1. It is obtained by subtracting the EPNL value corresponding to the measured value of the correlating parameter from the EPNL value corresponding to the reference value of the correlating parameter. The adjustment term Δ_3 should be added algebraically to the EPNL value calculated from the measured data (see 8.3.6).

Note- Representative data for jet aeroplanes are illustrated in Figure A2-12 which shows a curve of EPNL versus the engine control parameter μ . The EPNL data is adjusted to all other relevant reference conditions (aeroplane mass, speed, height and air temperature) and, at each value of μ , for the difference in noise between the installed engine and the flight manual standard of engine.

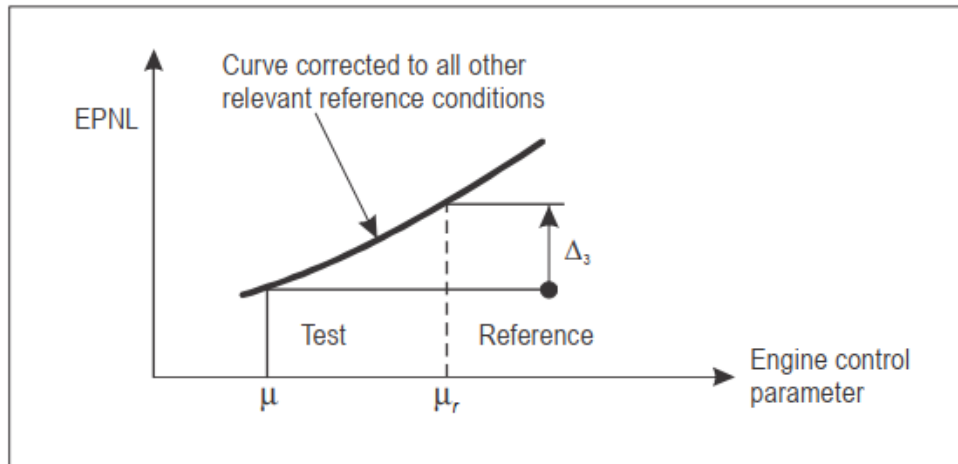


Figure A2-12. Source noise adjustment

8.3.5.3 For jet aeroplanes, noise data acquired from measurements conducted at test site locations at or above 366 m (1 200 ft) above mean sea level (MSL) should, in addition, be adjusted for the effects on jet source noise.

Note.—A procedure for determining and applying the adjustment for the effects on jet source noise is given in the section of the Environmental Technical Manual (Doc 9501), Volume I — Procedures for the Noise Certification of Aircraft, concerning noise data adjustments for tests at high altitude sites.

8.3.5.4 For jet aeroplanes, when the test and reference true airspeeds differ by more than 28 km/h (15 kt), the effect of the difference in airspeed on engine component noise sources and the consequential effect on the certification noise levels should be taken into account. Test data and/or analysis procedures used to quantify this effect should be approved by the certificating authority.

8.3.5.5 For helicopter overflight, if any combination of the following three factors results in the measured value of an agreed noise correlating parameter deviating from the reference value of this parameter, then source noise adjustments should be determined from manufacturer's data approved by the certificating authority:

- a) airspeed deviations from reference;
- b) rotor speed deviations from reference; and/or
- c) temperature deviations from reference.

This adjustment may normally be made using a sensitivity curve of $PNLTM_r$ versus advancing blade tip Mach number. The adjustment may be made using an alternative parameter, or parameters, approved by the certificating authority. The advancing blade tip Mach number, or agreed noise correlating parameter, may be computed from “as

measured” data. Separate curves of PNLTMR versus advancing blade tip Mach number, or another agreed noise correlating parameter, may be derived for each of the three certification microphone locations, centre line, left sideline and right sideline, defined relative to the direction of flight of each test run. If it is not possible during noise measurement tests to attain the reference value of advancing blade tip Mach number or the agreed reference noise correlating parameter, then an extrapolation of the sensitivity curve is permitted, provided the data cover an adequate range of values, agreed by the certificating authority, of the noise correlating parameter.

8.3.5.6 When using advancing blade tip Mach number is used, it shall be computed using true airspeed, on-board outside air temperature (OAT), and rotor speed.

8.3.5.7 For helicopters, the adjustment term Δ_3 , obtained according to 8.3.5.5, should be added algebraically to the EPNL value calculated from the measured data as described in 8.3.6.

8.3.6 Application of adjustment terms for simplified method

When the simplified adjustment method is used, the EPNL for reference conditions, $EPNL_r$, shall be determined by adding the adjustment terms identified in 8.3.2 through 8.3.5 to the EPNL calculated for measurement conditions as follows:

$$EPNL_r = EPNL + \Delta_1 + \Delta_{Peak} + \Delta_2 + \Delta_3$$

8.3.7 Lateral noise asymmetry

For the determination of the lateral noise level for jet aeroplanes, asymmetry (see Chapter 3, 3.3.2.2) should be accounted for as follows:

- a) if a symmetrical measurement point is opposite the point where the highest noise level is obtained, the certification noise level should be the (arithmetical) mean of the noise levels measured at these two points (see Figure A2-13 a));
- b) if not, it should be assumed that the variation of noise with the height of the aeroplane is the same on both sides (i.e. there is a constant difference of noise versus height on the two sides (see Figure A2-13 b)). The certification noise level should then be the maximum value of the mean between these lines.

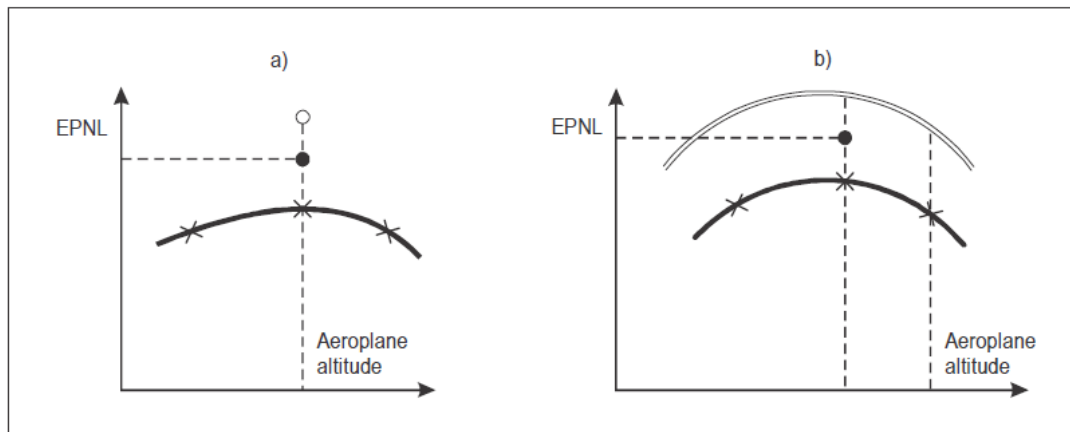


Figure A2-13. Lateral asymmetry adjustments

8.4 Integrated method of adjustment

8.4.1 General

8.4.1.1 The integrated method shall consist consists of recomputing, under reference conditions, points in the PNL_T time history corresponding to measured points obtained during the tests, and then computing EPNL directly for the new time history.

8.4.1.2 When the integrated adjustment method is used, the emission coordinates (time, X, Y, and Z) of the reference data point associated with each PNL_{T,r}(k) should be determined such that the acoustic emission angle θ on the reference flight path, relative to the reference microphone, is the same value as the acoustic emission angle of the as-measured data point associated with PNL_T(k).

Note.— As a consequence, and unless the test and reference conditions are identical, the reception time intervals between the reference data points will typically neither be equally-spaced nor equal to one-half second.

8.4.1.3 When the integrated adjustment method is used, the following calculations shall be made:

- a) The spectrum associated with each test-day data point, PNL_T(k), is adjusted for spherical spreading and attenuation due to atmospheric absorption, to reference conditions (see 8.4.2.1);
- b) A reference tone-corrected perceived noise level, PNL_{T,r}(k), is calculated for each one-third octave band spectrum (see 8.4.2.2);
- c) The maximum value, PNL_{TM,r} and first and last 10 dB-down points are determined from the PNL_{T,r} series (see 8.4.2.3 and 8.4.3.1);

- d) The effective duration, $\delta t_r(k)$, is calculated for each $PNLT_r(k)$ point, and the reference noise duration is then determined (see 8.4.3.2 and 8.4.3.3);
- e) The integrated reference condition effective perceived noise level, $EPNL_r$, is determined by the logarithmic summation of $PNLT_r(k)$ levels within the noise duration normalized to a duration of 10 seconds (see 8.4.4); and
- f) A source noise adjustment is determined and applied (see 8.4.5).

8.4.2 PNL_T computations

8.4.2.1 The measured values of $SPL(i,k)$ should be adjusted to the reference values $SPL_r(i,k)$ for the differences between measured and reference sound propagation path lengths and between measured and reference atmospheric conditions, by the methods of 8.3.2.1. Corresponding values of $PNL_r(k)$ should be computed as described in 4.2.

8.4.2.2 For each value of $PNL_r(k)$, a tone correction factor C should be determined by analysing each reference value $SPL_r(i,k)$ by the methods of 4.3, and added to $PNL_r(k)$ to obtain $PNLT_r(k)$.

8.4.2.3 The maximum reference condition tone corrected perceived noise level, $PNLTM_r$, should be identified, and a new reference condition bandsharing adjustment, Δ_{Br} , should be determined and applied as described in 4.4.2.

Note.-Due to differences between test and reference conditions, it is possible that the maximum $PNLT_r$ value will not occur at the data point associated with $PNLTM_r$. The determination of $PNLTM_r$ is independent of $PNLTM_r$.

8.4.3 Noise duration

8.4.3.1 The limits of the noise duration should be defined as the 10 dB-down points obtained from the series of reference condition $PNLT_r(k)$ values. Identification of the 10 dB-down points should be performed in accordance with 4.5.1. In the case of the integrated method, the first and last 10 dB-down points should be designated as k_{Fr} and k_{Lr} .

8.4.3.2 The noise duration for the integrated reference condition should be equal to the sum of the effective durations, $\delta t_r(k)$, associated with each of the $PNLT_r(k)$ data points within the 10 dB-down period, inclusive.

8.4.3.3 The effective duration, $\delta t_r(k)$, should be determined for each $PNLT_r(k)$ reference condition data point as follows:

$$\delta t_r(k) = [(t_r(k) - t_r(k-1)) + (t_r(k+1) - t_r(k))]/2$$

where:

$t_r(k)$ is the time associated with $PNLT_r(k)$;

$t_r(k-1)$ is the time associated with $PNLT_r(k-1)$, the data point preceding $PNLT_r(k)$; and

$t_r(k+1)$ is the time associated with $PNLT_r(k+1)$, the data point following $PNLT_r(k)$.

Note 1- Due to differences in flight path geometry, airspeed and sound speed between test and reference conditions, the times, $t_r(k)$, associated with the $PNLT_r(k)$ points projected to the reference flight path are likely to occur at varying, non-uniform time intervals.

Note 2- Relative values of time $t_r(k)$ for the reference data points can be determined by using the distance between such points on the reference flight path, and the reference aircraft airspeed V_r .

Note 3- The Environmental Technical Manual (Doc 9501), Volume I – Procedures for the Noise Certification of Aircraft, provides additional guidance for one method for performing the integrated procedure, including the determination of effective durations, $\delta t_r(k)$, for the individual data points of the reference time history.

8.4.4 Calculation of integrated reference condition EPNL

8.4.4.1 The equation for calculating reference condition EPNL using the integrated method, $EPNL_r$, is similar to the equation for test-day EPNL given in 4.6. However, the numerical constant related to one-half second intervals is eliminated, and a multiplier is introduced within the logarithm to account for the effective duration of each $PNLT_r(k)$ value, $\delta t_r(k)$. The reference condition EPNL using the integrated method, $EPNL_r$, shall be calculated with the following equation:

$$EPNL_r = 10 \log \frac{1}{T_0} \sum_{k_{Fr}}^{k_{Lr}} 10^{0.1PNLT_r(k)} \delta t_r(k)$$

where:


the reference time, T_0 , is 10 seconds;

k_{Fr} and k_{Lr} are the first and last 10 dB-down points as defined in 8.4.3.1; and

$\delta t_r(k)$ is the effective duration as defined in 8.4.3.3 of each reference condition $PNLT_r(k)$ value.


8.4.5 Source noise adjustment

8.4.5.1 Finally, a source noise adjustment should be determined by the methods of 8.3.5, and added to the $EPNL_r$ determined in 8.4.4.1.

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8.4.5.2 For jet aeroplanes, noise data acquired from measurements conducted at test site locations at or above 366 m (1 200 ft) above mean sea level (MSL) should, in addition, be adjusted for the effects on jet source noise.

***Note.** - A procedure for determining the adjustment for the effects on jet source noise is given in the section of the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft, concerning noise data adjustments for test at high altitude sites.*

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APPENDIX 3. EVALUATION METHOD FOR NOISE CERTIFICATION OF PROPELLER DRIVEN AEROPLANES NOT EXCEEDING 8618 KG.

Note-See Part II, Chapter 6.

1. INTRODUCTION

Note 1.- This noise evaluation method includes:

- a) noise certification test and measurement conditions;*
- b) measurement of aeroplane noise received on the ground; and*
- c) reporting of data to the certifying authority and correction of measured data.*

Note 2.- The instructions and procedures given in the method are clearly delineated to ensure uniformity during compliance tests, and to permit comparison between tests of various types of aeroplanes, conducted in various geographical locations. The method applies only to aeroplanes within the applicability clauses of Part II, Chapter 6.

2. NOISE CERTIFICATION TEST AND MEASUREMENT CONDITIONS

2.1 General

This section prescribes the conditions under which noise certification tests should be conducted and the measurement procedures that should be used to measure the noise made by the aeroplane for which the test is conducted.

2.2 General test conditions

2.2.1 Locations for measuring noise from an aeroplane in flight should be surrounded by relatively flat terrain having no excessive sound absorption characteristics such as might be caused by thick, matted or tall grass, shrubs or wooded areas. No obstructions which significantly influence the sound field from the aeroplane should exist within a conical space above the measurement position, the cone being defined by an axis normal to the ground and by a half-angle 75° from this axis.

2.2.2 The tests should be carried out under the following atmospheric conditions:

- a) no precipitation;
- b) relative humidity not higher than 95 per cent and not lower than 20 per cent and ambient temperature not above 35°C and not below 2°C at 1.2 m (4 ft) above ground except that on a diagram of temperature plotted against relative humidity

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combinations of temperature and relative humidity which fall below a straight line between 2°C and 60 per cent and 35°C and 20 per cent should be avoided;

- c) at 1.2 m (4 ft) above ground, instantaneous wind speed should not exceed 5.1 m/s (10 kt) and instantaneous crosswind speed should not exceed 2.6 m/s (5 kt). Flights should be made in equal numbers with tailwind and headwind components; and

Note.- The noise certification test windows for wind speed expressed in m/s are the result of converting historically used values expressed in knots using a conversion factor consistent with Part 5, Chapter 3, Table 3-3, and rounded to 0.1 m/s. The values as given here, expressed in either unit, are considered equivalent for establishing adherence to the wind speed test windows for noise certification purposes.

- d) no temperature inversions or anomalous wind conditions that would significantly affect the noise level of the aeroplane when the noise is recorded at the measuring points specified by the certificating authority.

2.3 Aeroplane testing procedures

2.3.1 The test procedures and noise measurement procedure should be acceptable to the airworthiness and noise certificating authorities of the State issuing the certification.

2.3.2 The aeroplane height and lateral position relative to the microphone should be determined by a method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation, photographic scaling techniques, or other methods to be approved by the certificating authority.

3. MEASUREMENT OF AEROPLANE NOISE RECEIVED ON THE GROUND

3.1 General

3.1.1 All measuring equipment should be approved by the certificating authority.

3.1.2 Sound pressure level data for noise evaluation purposes should be obtained with acoustical equipment and measurement practices that conform to the specifications given hereunder in 3.2.

3.2 Measurement system

The acoustical measurement system should consist of approved equipment equivalent to the following:

- a) a microphone system with frequency response compatible with measurement and analysis system accuracy as stated in 3.3;

- b) tripods or similar microphone mountings that minimize interference with the sound being measured;
- c) recording and reproducing equipment characteristics, frequency response, and dynamic range compatible with the response and accuracy requirements of 3.3; and
- d) acoustic calibrators using sine wave or broadband noise of known sound pressure level. If broadband noise is used, the signal should be described in terms of its average and maximum root-mean-square (rms) value of non-overload signal level.

3.3 Sensing, recording and reproducing equipment

3.3.1 When so specified by the certifying authority, the sound produced by the aeroplane should be recorded in such a way that the complete information, including time history, is retained. A magnetic tape recorder is acceptable.

3.3.2 The characteristics of the complete system should comply with the recommendations given in International Electrotechnical Commission (IEC) Publication No. 179¹ with regard to the sections concerning microphone, amplifier and indicating instrument characteristics. The text and specifications of IEC Publication No. 179¹ entitled “Precision Sound Level Meters” are incorporated by reference into this section and are made a part hereof.


Note.- When a tape recorder is used, it forms part of the complete system complying with IEC Recommendation 561.¹

3.3.3 The response of the complete system to a sensibly plane progressive sinusoidal wave of constant amplitude should lie within the tolerance limits specified in Table IV and Table V for Type I instruments in IEC Publication No. 179,¹ for weighting curve “A” over the frequency range 45 to 11 200 Hz.

3.3.4 The recorded noise signal should be read through an “A” filter as defined in IEC Publication No. 179,¹ and with dynamic characteristics designated “slow”.

Note- During tests with high flight speeds, the “fast” dynamic characteristics may be necessary to obtain the true level.

3.3.5 The equipment should be acoustically calibrated using facilities for acoustic free-field calibration. The overall sensitivity of the measuring system should be checked before and after the measurement of the noise level for a sequence of aeroplane operations, using an acoustic calibrator generating a known sound pressure level at a known frequency.

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Note- A pistonphone operating at a nominal 124 dB and 250 Hz is generally used for this purpose.

3.3.6 A windscreen should be employed with the microphone during all measurements of aeroplane noise when the wind speed is in excess of 3 m/s (6 kt). Its characteristics should be such that when it is used, the complete system including the windscreen will meet the specifications above. Its insertion loss at the frequency of the acoustic calibrator should also be known and included in the provision of an acoustic reference level for the analysis of the measurements.

3.4 Noise measurement procedures

3.4.1 The microphones should be oriented in a known direction so that the maximum sound received arrives as nearly as possible in the direction for which the microphones are calibrated. The microphones should be placed so that their sensing elements are approximately 1.2 m (4 ft) above ground.

3.4.2 Immediately prior to and after each test, a recorded acoustic calibration of the system should be made in the field with an acoustic calibrator for the two purposes of checking system sensitivity and providing an acoustic reference level for the analysis of the sound level data.

1. As amended. Available from the Central Office of the International Electrotechnical Commission, 3 rue de Varembé, Geneva, Switzerland.

3.4.3 Background noise, including ambient noise and electrical noise of the measurement systems, should be recorded and determined in the test area with the system gain set at levels which will be used for aeroplane noise measurements. If aeroplane sound pressure levels do not exceed background sound pressure levels by at least 10 dB(A), approved corrections for the contribution of background sound pressure level to the observed sound pressure level should be applied.

4. REPORTING OF DATA TO THE CERTIFICATING AUTHORITY AND CORRECTION OF MEASURED DATA

4.1 Data reporting

4.1.1 Measured and corrected sound pressure levels obtained with equipment conforming to the specifications described in Section 3 of this appendix should be reported.

4.1.2 The type of equipment used for measurement and analysis of all acoustic aeroplane performance and meteorological data should be reported.

4.1.3 The following atmospheric environmental data, measured immediately before, after, or

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during each test at the observation points prescribed in Section 2 of this appendix should be reported:

- a) air temperature and relative humidity; and
- b) maximum, minimum and average wind velocities.

4.1.4 Comments on local topography, ground cover, and events that might interfere with sound recordings should be reported.

4.1.4 The following aeroplane information should be reported:


- a) type, model and serial numbers of aeroplane, engine(s) and propeller(s);
- b) any modifications or non-standard equipment likely to affect the noise characteristics of the aeroplane;
- c) maximum certificated take-off mass;
- d) for each overflight, airspeed and air temperature at the flyover altitude determined by properly calibrated instruments;
- e) for each overflight, engine performance as manifold pressure or power, propeller speed in revolutions per minute and other relevant parameters determined by properly calibrated instruments;
- f) aeroplane height above ground (see 2.3.2);
- g) corresponding manufacturer's data for the reference conditions relevant to 4.1.5 d) and e).

4.2 Data correction

4.2.1 Correction of noise at source

4.2.1.1 When so specified by the certificating authority, corrections for differences between engine power achieved during the tests and the power that would be achieved at settings corresponding to the highest power in the normal operating range by an average engine of the type under reference conditions should be applied using approved methods.

4.2.1.2 At a propeller helical tip Mach number at or below 0.70 no correction is required if the test helical tip Mach number is within 0.014 of the reference helical tip Mach number. At a propeller helical tip Mach number above 0.70 and at or below 0.80 no correction is required if the test helical tip Mach number is within 0.007 of the reference helical tip Mach number. Above a helical tip Mach number of 0.80 no correction is required if the helical tip Mach number is within 0.005 of the reference helical tip Mach number. If the test power at any helical tip Mach number is within 10 per cent of the reference power,

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no correction for source noise variation with power is required. No corrections are to be made for power changes for fixed pitch propeller-driven aeroplanes. If test propeller helical tip Mach number and power variations from reference conditions are outside these constraints, corrections based on data developed using the actual test aeroplane or a similar configured aeroplane with the same engine and propeller operating as the aeroplane being certificated should be used as described in the section of the *Environmental Technical Manual* (Doc 9501), Volume I - *Procedures for the Noise Certification of Aircraft*, concerning source noise adjustments for aeroplanes evaluated under this appendix.

4.2.2 Correction of noise received on the ground

The noise measurements made at heights different from 300 m (985 ft) should be adjusted to 300 m (985 ft) by the inverse square law.

4.2.3 Performance correction

Note.-The performance correction is intended to credit higher performance aeroplanes based on their ability to climb at a steeper angle and to fly the traffic pattern at a lower power setting. Also, this correction penalizes aeroplanes with limited performance capability which results in lower rates of climb and higher power settings in the traffic pattern.

4.2.3.1 A performance correction determined for sea level, 15°C conditions and limited to a maximum of 5 dB(A) should be applied using the method described in 4.2.3.2 and added algebraically to the measured value.

4.2.3.2 The performance correction should be calculated by using the following formula:

$$\Delta\text{dB} = 49.6 - 20 \log \left[(3\,500 - D_{15}) \frac{R/C}{V_y} + 15 \right]$$

where D_{15} = Take-off distance to 15 m at maximum certificated take-off mass and maximum take-off power (paved runways)


R/C = Best rate of climb at maximum certificated take-off mass and maximum take-off power

V_y = Climb speed corresponding to R/C at maximum take-off power and expressed in the same units.

Note.- When take-off distance is not certificated, the figure of 610 m for single-engined aeroplanes and 825 m for multi-engined aeroplanes is used.


4.3 Validity of results

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- 4.3.1 The measuring point should be overflown at least four times. The test results should produce an average dB(A) value and its 90 per cent confidence limits, the noise level being the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point.
- 4.3.2 The samples should be large enough to establish statistically a 90 per cent confidence limit not exceeding ± 1.5 dB(A). No test result should be omitted from the averaging process, unless otherwise specified by the certificating authority.

Note- Methods for calculating the 90 per cent confidence interval are given in the section of the Environmental Technical Manual (Doc 9501), Volume I - Procedures for the Noise Certification of Aircraft, concerning calculation of confidence intervals.

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APPENDIX 4. EVALUATION METHOD FOR NOISE CERTIFICATION OF HELICOPTERS NOT EXCEEDING 3175 kg MAXIMUM CERTIFICATED TAKE-OFF MASS

Note.- See Part II, Chapter 11.

1. INTRODUCTION

Note 1-This noise evaluation method includes:

- a) noise certification test and measurement conditions;*
- b) definition of sound exposure level using measured noise data;*
- c) measurement of helicopter noise received on the ground;*
- d) adjustment of flight test results; and*
- e) reporting of data to the certifying authority.*

Note 2- The instructions and procedures given in the method are intended to ensure uniformity during compliance tests of various types of helicopters conducted in various geographical locations. The method applies only to helicopters meeting the applicability clauses of Part II, Chapter 11, of this Part.

2. NOISE CERTIFICATION TEST AND MEASUREMENT CONDITIONS

2.1 General

This section prescribes the conditions under which noise certification should be conducted and the meteorological and flight path measurement procedures that should be used.

2.2 Test environment

2.2.1 The location for measuring noise from the helicopter in flight should be surrounded by relatively flat terrain having no excessive ground absorption characteristics such as might be caused by thick, matted or tall grass, shrubs or wooded areas. No obstructions which significantly influence the sound field from the helicopter should exist within a conical space above the test noise measurement position, the cone being defined by an axis normal to the ground and by a half-angle of 80° from this axis.

Note—Those people carrying out the measurements could themselves constitute such obstructions.

2.2.2 The tests should be carried out under the following atmospheric conditions:

- a) no precipitation;
- b) relative humidity not higher than 95 per cent or lower than 20 per cent and ambient temperature not above 35°C and not below 2°C at a height between 1.2

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m (4 ft) and 10 m (33 ft) above ground; combinations of temperature and humidity which lead to an absorption coefficient in the 8 KHz one-third octave band of greater than 10 dB/100 m should be avoided;

Note.-Absorption coefficients as a function of temperature and relative humidity are given in Section 7 of Appendix 2 or SAE ARP 866A.

- c) at a height between 1.2 m (4 ft) and 10 m (33 ft) above ground, average wind speed should not exceed 5.1 m/s (10 kt) and the average crosswind component should not exceed 2.6 m/s (5 kt); and

Note.- The noise certification test windows for wind speed expressed in m/s are the result of converting historically used values expressed in knots using a conversion factor consistent with Part 5, Chapter 3, Table 3-3, and rounded to 0.1 m/s. The values as given here, expressed in either unit are considered equivalent for establishing adherence to the wind speed test windows for noise certification purposes.

- d) no other anomalous meteorological conditions that would significantly affect the noise level when recorded at the measuring points specified by the certifying authority.

Note.- Meteorological specifications are given in Section 2.2.2.1 of Appendix 2.

- 2.2.3 The atmospheric conditions should be measured within 2 000 m (6 562 ft) from the microphone locations and should be representative of the conditions existing over the geographical area in which noise measurements are made.

2.3 Flight path measurement

- 2.3.1 The helicopter position relative to the flight path reference point should be determined by a method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation or photographic scaling techniques, approved by the certifying authority.

- 2.3.2 Position and performance data required to make the adjustments referred to in Section 5 of this appendix should be recorded at an approved sampling rate. Measuring equipment should be approved by the certifying authority.

2.4 Flight test conditions

- 2.4.1 The helicopter should be flown in a stabilized flight condition over a distance sufficient to ensure that the time-varying sound level is measured during the entire time period during which the sound level is within 10 dB(A) of the maximum A-frequency-weighted S-time-weighted sound level (L_{ASmax}) measured during the test run..

- 2.4.2 The helicopter flyover noise test should be conducted at the airspeed referred to in Part II, Chapter 11, 11.5.2, with such airspeed adjusted as necessary to produce the same advancing blade tip Mach number as the reference advancing blade tip Mach number, MATR, which is defined as:



$$M_{ATR} = \frac{(V_{tipR} + V_R)}{c_R}$$

where:

V_{tipR} is the blade tip rotational speed;

V_R is the reference helicopter true airspeed; and

c_R is the speed of sound, at 25°C:

$$M_{ATR} = \frac{(V_{tipR} + V_R)}{c_R}$$

3. NOISE UNIT DEFINITION

3.1 The sound exposure level L_{AE} shall represent the level, in decibels, of the time integral of squared A-weighted sound pressure (P_A) over a given time period or event, with reference to the square of the standard reference sound pressure (P_0) of 20 μ Pa and a reference duration of one second.

3.2 In practice, L_{AE} is obtained from periodically sampled measurement as:

$$L_{AE} = 10 \log \frac{1}{t_0} \sum_{k_F}^{k_L} 10^{0.1L_{AS}(k)} \Delta t$$

where $L_{AS}(k)$ is the time varying A-frequency-weighted S-time-weighted sound level measured at the k-th instant of time, k_F and k_L are the first and last increment of k, and Δt is the time increment between samples.

3.2 The time interval $k_L - k_F$ in practice should not be less than the 10 dB-down period during which $L_{AS}(t)$ first rises to 10 dB(A) below its maximum value and last falls below 10 dB(A) of its maximum value.

Note. the time integral referred to in 3.1 is expressed as:

$$L_{AE} = 10 \log \frac{1}{t_0} \int_{t_1}^{t_2} \left(\frac{p_A(t)}{P_0} \right)^2 dt$$

where t_0 is the reference integration time of one second and $(t_2 - t_1)$ is the integration time interval.

4. MEASUREMENT OF HELICOPTER NOISE RECEIVED ON THE GROUND

4.1 General

4.1.1 All measuring equipment should be approved by the certifying authority.

4.1.2 Sound pressure level data for noise evaluation purposes should be obtained with acoustical equipment and measurement practices that conform to the specifications given in 4.2.

4.2 Measurement system

The acoustical measurement system should consist of approved equipment equivalent to the following:

- a) a microphone system with performance characteristics meeting the requirements of 4.3;
- b) tripods or similar microphone mountings that minimize interference with the sound being measured;
- c) recording and reproducing equipment with performance characteristics meeting the requirements of 4.3; and
- d) sound calibrators using sine wave signals of known sound pressure level meeting the requirements of 4.3.

4.3 Sensing, recording and reproducing equipment

4.3.1 The microphone should be of the type that has a pressure or a diffuse-field sensitivity whose frequency response is nearly flat at grazing incidence.

4.3.2 The L_{AE} may be directly determined from an integrating sound level meter. Alternatively, with the approval of the certifying authority the sound pressure signal produced by the helicopter may be stored on an analogue magnetic tape recorder or a digital audio recorder for later evaluation using an integrating sound level meter. The L_{AE} may also be calculated from one-third octave band data obtained from measurements made in conformity with Section 3 of Appendix 2 and using the equation given in 3.3. In this case each one-third octave band sound pressure level should be weighted in accordance with the A-weighting values given in IEC Publication 61672-1.¹


4.3.3 The characteristics of the complete system with regard to directional response, frequency weighting A, time weighting S (slow), level linearity, and response to short-duration signals should comply with the class 1 specifications given in IEC 61672-1.¹ The complete system may include tape recorders or digital audio recorders according to IEC 61672-1.¹ The certifying authority may approve the use of equipment compliant with

class 2 of the current IEC standard, or the use of equipment compliant with class 1 or Type 1 specifications of an earlier standard, if the applicant can show that the equipment had previously been approved for noise certification use by a certifying authority. This includes the use of a sound level meter and graphic level recorder to approximate SEL using the equation given in 3.1. The certifying authority may also approve the use of magnetic tape recorders that comply with the specifications of the older IEC 561 standard if the applicant can show that such use had previously been approved for noise certification use by a certifying authority.

- 4.3.4 The overall sensitivity of the measurement system should be checked before the start of testing, after testing has ended and at intervals during testing using a sound calibrator generating a known sound pressure level at a known frequency. The sound calibrator should conform to the class 1 requirements of IEC 60942.² The output of the sound calibrator should have been checked by a standardizing laboratory within 6 months of each aircraft noise measurement. Tolerable changes in output should be not more than 0.2 dB. Measured aircraft noise data should not be considered valid for certification purposes unless preceded and succeeded by valid sound pressure level calibrations. The measurement system should be considered satisfactory if the difference between the acoustical sensitivity levels recorded immediately before and immediately after each group of aircraft noise measurements on a given day is not greater than 0.5 dB. The certifying authority may approve the use of calibrators compliant with class 2 of the current IEC standard, or the use of calibrators compliant with class 1 of an earlier standard, if the applicant can show that the calibrator had previously been approved for noise certification use by a certifying authority.
- 4.3.5 When the sound pressure signals from the helicopter are recorded, the L_{AE} may be determined by playback of the recorded signals into the electrical input facility of an approved sound level meter that conforms to the class 1 performance requirements of IEC 61672-1.¹ The acoustical sensitivity of the sound level meter should be established from playback of the associated recording of the signal from the sound calibrator and knowledge of the sound pressure level produced in the coupler of the sound calibrator under the environmental conditions prevailing at the time of the recording of the sound from the helicopter.
- 4.3.6 A windscreen should be employed with the microphone during all measurements of helicopter sound levels. Its characteristics should be such that when it is used, the complete system including the windscreen will meet the specifications in 4.3.3.

1. IEC 61672-1: 2002 entitled “Electroacoustics — Sound level meters — Part I: Specifications”. This IEC publication may be obtained from the Bureau central de la Commission électrotechnique internationale, 3 rue de Varembe, Geneva, Switzerland.

2. IEC 60942: 2003 entitled “Electroacoustics — Sound calibrators”. This IEC publication may be

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obtained from the Bureau central de la Commission électrotechnique internationale, 3 rue de Varembe, Geneva, Switzerland.

4.4 Noise measurement procedures

4.4.1 The microphone should be mounted with the center of the sensing element 1.2 m (4 ft) above the local ground surface and should be oriented for grazing incidence, i.e. with the sensing element substantially in the plane defined by the nominal flight path of the helicopter and the measuring station. The microphone mounting arrangement should minimize the interference of the supports with the sound to be measured.

4.4.2 If the helicopter sound pressure signal is recorded, the frequency response of the electrical system should be determined, during each test series, at a level within 10 dB of the full-scale reading used during the tests, utilizing random or pseudo-random pink noise. The output of the noise generator should have been checked by an approved standards laboratory within six months of the test series, and tolerable changes in the relative output at each one-third octave band should be not more than 0.2 dB. Sufficient determinations should be made to ensure that the overall calibration of the system is known for each test.

4.4.3 Where an analogue magnetic tape recorder forms part of the measuring chain, each reel of magnetic tape should carry 30 s of this electrical calibration signal at its beginning and end for this purpose. In addition, data obtained from tape-recorded signals should be accepted as reliable only if the level difference in the 10 kHz one-third octave band filtered levels of the two signals is not more than 0.75 dB.

Note.—Digital audio recorders compliant with class 1 performance specifications of IEC 61672-1¹ typically do not exhibit substantial variation with time in frequency response or level sensitivity; therefore the pink noise testing described in 4.4.3 is not necessary for digital audio recorders.

4.4.4 The A-frequency-weighted sound level of the background noise, including ambient noise and electrical noise of the measurement systems, should be determined in the test area with the system gain set at levels which will be used for helicopter noise measurements. If the L_{Amax} of each test run does not exceed the A-frequency-weighted sound level of the background noise by at least 15 dB(A), flyovers at an approved lower height may be used and the results adjusted to the reference measurement height by an approved method.

5. ADJUSTMENT TO TEST RESULTS

5.1 When certification test conditions differ from the reference conditions, appropriate adjustments should be made to the measured noise data by the methods of this section.

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5.2 Corrections and adjustments

5.2.1 The adjustments referred to in 5.1 may be limited to the effects of differences in spherical spreading between the helicopter test flight path and the reference flight path (and between reference and adjusted reference airspeed). No adjustment for the differences in atmospheric attenuation between the test and reference meteorological conditions and between the helicopter test and reference ground speeds need be applied.

5.2.2 The adjustments for spherical spreading and duration may be approximated from:

$$\Delta_1 = 12.5 \log (H/150) \text{ dB}$$

where H is the height, in metres, of the test helicopter when directly over the noise measurement point.

5.2.3 The adjustment for the difference between reference airspeed and adjusted reference airspeed may be calculated from:

$$\Delta_2 = 10 \log \left(\frac{V_{AR}}{V_R} \right)$$

where Δ_2 is the quantity in decibels that shall be algebraically added to the measured L_{AE} noise level to correct for the influence of the adjustment of the reference airspeed on the duration of the measured flyover event as perceived at the noise measurement station. V_r is the reference airspeed as prescribed under Part II, Chapter 11, 11.5.2, and V_{ar} is the adjusted reference airspeed as prescribed in 2.4.2 of this appendix.

6. REPORTING OF DATA TO THE CERTIFICATING AUTHORITY AND VALIDITY OF RESULTS

6.1 Data reporting


- 6.1.1 Measured and corrected sound pressure levels obtained with equipment conforming to the specifications described in Section 4 of this appendix should be reported.
- 6.1.2 The type of equipment used for measurement and analysis of all acoustic helicopter performance and meteorological data should be reported.
- 6.1.3 The following atmospheric environmental data, measured immediately before, after, or during each test at the observation point prescribed in Section 2 of this appendix should be reported:
- a) air temperature and relative humidity;
 - b) wind speeds and wind directions; and
 - c) atmospheric pressure.
- 6.1.4 Comments on local topography, ground cover and events that might interfere with sound recording should be reported.
- 6.1.5 The following helicopter information should be reported:
- a) type, model and serial numbers of helicopter, engine(s) and rotor(s);
 - b) any modifications or nonstandard equipment likely to affect the noise characteristics of the helicopter;
 - c) maximum certificated take-off and landing mass;
 - d) indicated airspeed in kilometres per hour (knots) and rotor speed in rpm during each demonstration;
 - e) engine performance parameters during each demonstration; and
 - f) helicopter height above the ground during each demonstration.

6.2 Reporting of noise certification reference conditions

Helicopter position and performance data and noise measurements should be corrected to the noise certification reference conditions specified in Part II, Chapter 11, 11.5. These conditions, including reference parameters, procedures and configurations should be reported.

6.3 Validity of results

- 6.3.1 The measuring point should be overflown at least six times. The test results should produce an average L_{AE} and its 90 per cent confidence limits, the noise level being the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point for the reference procedure.

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6.3.2 The sample should be large enough to establish statistically a 90 per cent confidence limit not exceeding ± 1.5 dB(A). No test results should be omitted from the averaging process unless approved by the certifying authority.

***Note-** Methods for calculating the 90 per cent confidence interval are given in in the section of the Environmental Technical Manual (Doc 9501), Volume I — Procedures for the Noise Certification of Aircraft concerning the calculation of confidence intervals.*

APPENDIX 5. MONITORING AIRCRAFT NOISE ON AND IN THE VICINITY OF AERODROMES

Note.- See Part III.

1. INTRODUCTION

Note 1.- *The introduction of jet aircraft operations, as well as the general increase in air traffic, has resulted in international concern over aircraft noise. To facilitate international collaboration on the solution of aircraft noise problems this appendix recommends a procedure for monitoring aircraft noise on and in the vicinity of.*

Note 2.- *In this appendix monitoring is understood to be the routine measurement of noise levels created by aircraft in the operation of an aerodrome. Monitoring usually involves a large number of measurements per day, from which an immediate indication of the noise level may be required.*

Note 3.- *This appendix specifies the measuring equipment to be used in order to measure noise levels created by aircraft in the operation of an aerodrome. The noise levels measured according to this appendix are approximations to perceived noise levels PNL, in PNdB, as calculated by the method described in Appendix 1, 4.2.*

1.1 Monitoring of aircraft noise should be carried out either with mobile equipment, often using only a sound level meter, or with permanently installed equipment incorporating one or more microphones with amplifiers located at different positions in the field with a data transmission system linking the microphones to a central recording installation. This appendix describes primarily the latter method, but specifications given in this appendix should also be followed, to the extent the specifications are relevant, when using mobile equipment.

2. DEFINITION

Monitoring of aircraft noise is defined as the routine measurement of noise levels created by aircraft on and in the vicinity of aerodromes for the purpose of monitoring compliance with and checking the effectiveness of noise abatement requirements.

3. MEASUREMENT EQUIPMENT

3.1 The measurement equipment should consist of either portable recording apparatus capable of direct reading, or apparatus located at one or more fixed positions in the field linked through a radio transmission - or cable system (e.g. telephone line) to a centrally located recording device.

3.2 The characteristics of the field equipment, including the transmission system, should comply with IEC Publication No. 179,¹ "Precision Sound Level Meters", except that frequency weighting equal to the inverse of the 40 noy contour


1. This publication was first issued in 1965 by the Central Office of the International Electro technical Commission, 3 rue de Varembé, Geneva, Switzerland.

(see Figure A5-1) should apply. An approximation, to the nearest decibel, of the inverse of the 40 noy contour relative to the value at 1 000 Hz is given in Table A5-1. The relative frequency response of the weighting element of the equipment should be maintained within a tolerance of ± 0.5 dB. When such a weighting network is incorporated in a direct-reading instrument, the relation between the acoustical input to the microphone and the meter reading should follow the inverse of the 40 noy contour with the same tolerances as those specified for weighting curve C in IEC Publication No. 179.² Measurements obtained by means of the instrumentation described above provide, after adding 7 dB, values which are approximations to the perceived noise levels in PNdB.

- 3.3 An alternative method of determining approximations to the perceived noise levels can be obtained from measuring the noise using a sound-level meter incorporating the A-weighting network³ and adding a correction K normally between 9 and 14 dB dependent on the frequency spectrum of the noise. The value of K and the method used by the measuring authorities for determination of that value should be specified when reporting results.
- 3.4 The field installation of microphones for aircraft noise monitoring purposes should provide for suitable protection of the microphones from rain, snow and other adverse weather conditions. Adequate correction for any insertion loss, as a function of frequency and weather conditions, produced by windscreens or other protective enclosures should be applied to the measured data. If required, a record of the noise as a function of time can be obtained by recording the noise signal on a magnetic tape, a graphic level recorder or other suitable equipment.
- 3.5 The recording and indicating equipment should comply with IEC Publication No. 179² regarding the dynamic characteristics of the indicating instrument designated as “slow”, If the anticipated duration of the noise signal is less than 5 s, the dynamic characteristics designated as “fast” may be used.
- 3.6 The microphone system should have been originally calibrated at a laboratory equipped for free-field calibration and its calibration should be rechecked at least every six months.

Table A5-1. Approximation to the nearest decibel of the inverse of the 40 noy contour relative to the value at 1 000 Hz

Hz	40	50	63	80	100	125	160
dB	-14	-12	-11	-9	-7	-6	-5
Hz	200	250	315	400	500	630	800
dB	-3	-2	-1	0	0	0	0
Hz	1 000	1 250	1 600	2 000	2 500	3 150	4 000
dB	0	+2	+6	+8	+10	+11	+11
Hz	5 000	6 300	8 000	10 000	12 500		
dB	+10	+9	+6	+3	0		

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2. This publication was first issued in 1965 by the Central Office of the International Electrotechnical Commission, 3 rue de Varembe, Geneva, Switzerland.
3. The A-weighting network is described in IEC Publication No. 179.

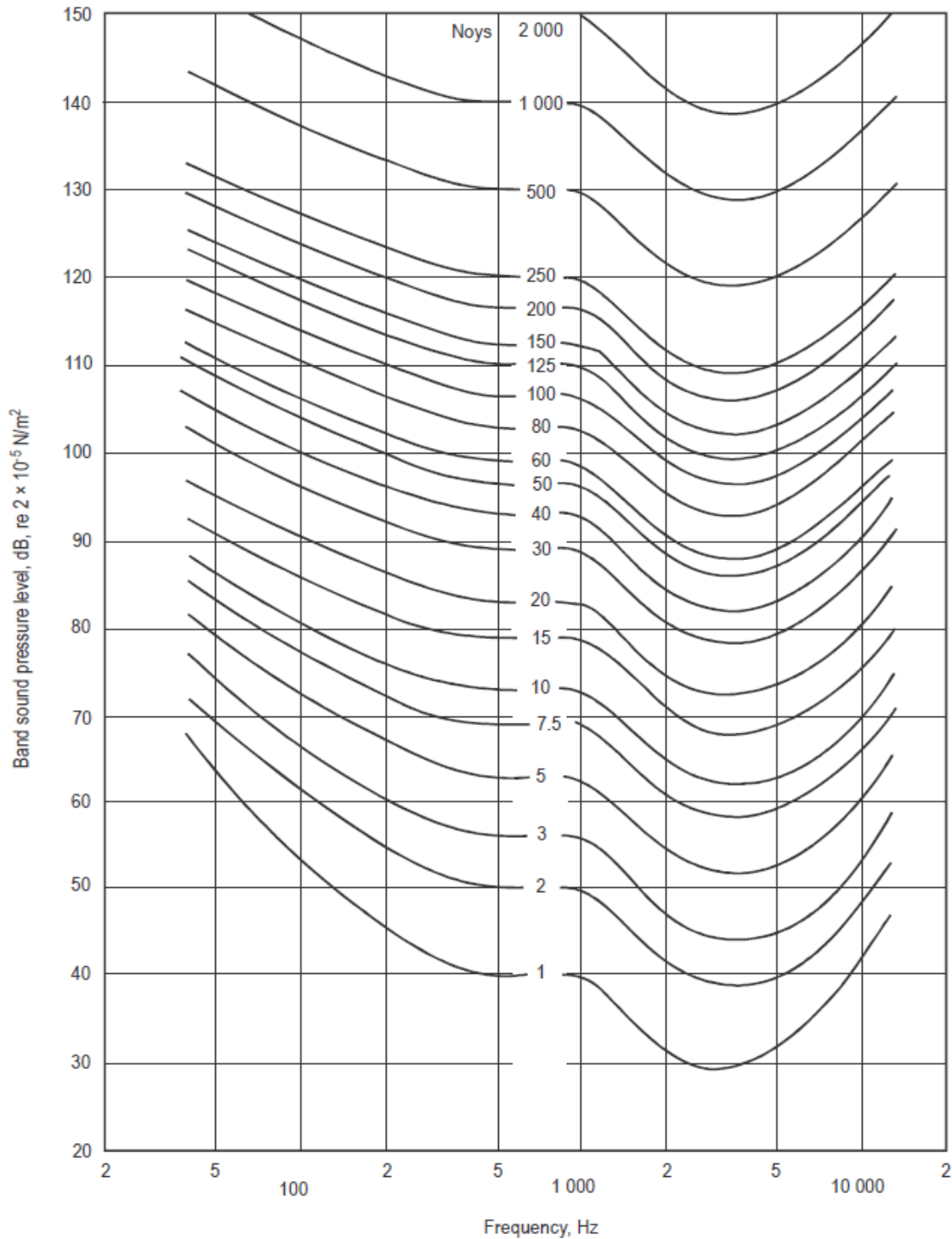


Figure A5-1. Contours of perceived noisiness

- 3.7 The complete measurement system prior to field installation and at periodic intervals thereafter should be calibrated in a laboratory to ensure that the frequency response and dynamic range requirements of the system comply with the specifications described in this document.
- 3.8 Direct-reading measuring systems that yield approximate values of perceived noise levels other than those defined above are not meant to be excluded from use in monitoring.

4. FIELD EQUIPMENT INSTALLATION

- 4.1 Microphones used for monitoring noise levels from aircraft operations should be installed at appropriate locations with the axis of maximum sensitivity of each microphone oriented in a direction such that the highest sensitivity to sound waves is achieved. The microphone position should be selected so that no obstruction which influences the sound field produced by an aircraft exists above a horizontal plane passing through the active center of the microphone. Monitoring microphones may need to be placed in locations having substantial background noise levels caused by motor vehicle traffic, children playing, etc. In these instances it is often expedient to locate the microphone on a rooftop, telephone pole or other structure rising above the ground. Consequently, it is necessary to determine the background noise level and to carry out a field check, at one or more frequencies, of the overall sensitivity of the measuring system after or before the measurement of the noise level for a sequence of aircraft operations. If, due to the microphone being placed in a structure above the ground, it is impracticable for operating personnel to calibrate it directly because of its inaccessibility, it can be useful to provide a calibrated sound source at the microphone location. This sound source can be a small loudspeaker, an electrostatic actuator, or similar device.
- 4.2 Monitoring concerns the noise produced by a single aircraft flight, by a series of flights or by a specified type of aircraft, or by a large number of operations of different aircraft. Such noise levels vary, for a specific monitoring location, with variations in flight procedures or meteorological conditions. In interpretation of the results of a monitoring procedure, consideration should therefore be given to the statistical distribution of the measured noise levels. In describing the results of a monitoring procedure an appropriate description of the distribution of the observed noise levels should be provided.

APPENDIX 6. EVALUATION METHOD FOR NOISE CERTIFICATION OF PROPELLER-DRIVEN AEROPLANES NOT EXCEEDING 8618 kg — Application for Type Certificate or Certification of Derived Version submitted on or after 17 November 1988

Note.— See Part II, Chapter 10.

1. INTRODUCTION

Note 1.— This noise evaluation method includes:

- a) noise certification test and measurement conditions;
- b) noise unit;
- c) measurement of aeroplane noise received on the ground;
- d) adjustments to test data; and
- e) reporting of data to the certifying authority and validity of results.

Note 2.- The instructions and procedures given in the method are clearly delineated to ensure uniformity during compliance tests and to permit comparison between tests of various types of aeroplanes, conducted in various geographical locations. The method applies only to aeroplanes within the applicability clauses of Part II, Chapter 10.


2. NOISE CERTIFICATION TEST AND MEASUREMENT CONDITIONS

2.1 General

This section prescribes the conditions under which noise certification tests should be conducted and the measurement procedures that should be used to measure the noise made by the aeroplane for which the test is conducted.

2.2 General test conditions

- 2.2.1 Locations for measuring noise from an aeroplane in flight should be surrounded by relatively flat terrain having no excessive sound absorption characteristics such as might be caused by thick, matted or tall grass, shrubs or wooded areas. No obstructions which significantly influence the sound field from the aeroplane should exist within a conical space above the measurement position, the cone being defined by an axis normal to the ground and by a half-angle 75° from this axis.

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2.2.2 The tests should be carried out under the following atmospheric conditions:

- a) no precipitation;
- b) relative humidity not higher than 95 per cent and not lower than 20 per cent and ambient temperature not above 35°C and not below 2°C;
- c) average wind speed should not exceed 5.1 m/s (10 kt) and crosswind average wind speed should not exceed 2.6 m/s (5 kt);

Note 1.- Meteorological specifications are defined in Section 2.2.2.1 of Appendix 2.

Note 2.- The noise certification test windows for wind speed expressed in m/s are the result of converting historically used values expressed in knots using a conversion factor consistent with Part 5, Chapter 3, Table 3-3, and rounded to 0.1 m/s. The values as given here, expressed in either unit are considered equivalent for establishing adherence to the wind speed test windows for noise certification purposes.

- d) no other anomalous meteorological conditions that would significantly affect the noise level of the aeroplane when the noise is recorded at the measuring points specified by the certificating authority; and
- e) the meteorological measurements shall be made between 1.2 m and 10 m above ground level. If the measurement site is within 2000 m of an airport meteorological station, measurements from this station may be used.

2.2.3 The atmospheric conditions should be measured within 2000 m (6 562 ft) from the microphone locations and should be representative of the conditions existing over the geographical area in which noise measurements are made.

2.3 Aeroplane testing procedures

2.3.1 The test procedures and noise measurement procedure should be acceptable to the airworthiness and noise certificating authorities of the State issuing the certification.

2.3.2 The flight test programme should be initiated at the maximum take-off mass for the aeroplane, and the mass should be adjusted to maximum take-off mass after each hour of flight time.

2.3.3 The flight test should be conducted at $V_y \pm 9$ km/h ($V_y \pm 5$ kt) indicated airspeed.

2.3.4 The aeroplane position relative to the flight path reference point should be determined by a method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation or photographic scaling techniques, approved by the certificating authorities.

2.3.5 The aeroplane height when directly over the microphone should be measured by an approved technique. The aeroplane should pass over the microphone within $\pm 10^\circ$ from the vertical and within ± 20 per cent of the reference height (see Figure A6-1).

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- 2.3.6 Aeroplane speed, position and performance data required to make the adjustments referred to in Section 5 of this appendix should be recorded when the aeroplane is directly over the measurement site. Measuring equipment should be approved by the certifying authority.
- 2.3.7 An independent device accurate to within ± 1 per cent should be used for the measurement of propeller rotational speed to avoid orientation and installation errors when the test aeroplane is equipped with mechanical tachometers.

3. NOISE UNIT DEFINITION

The L_{Amax} shall be determined as the maximum level, in decibels, of the A-weighted sound pressure (slow response) with reference to the square of the standard reference sound pressure (P_0) of 20 micropascals (μPa).

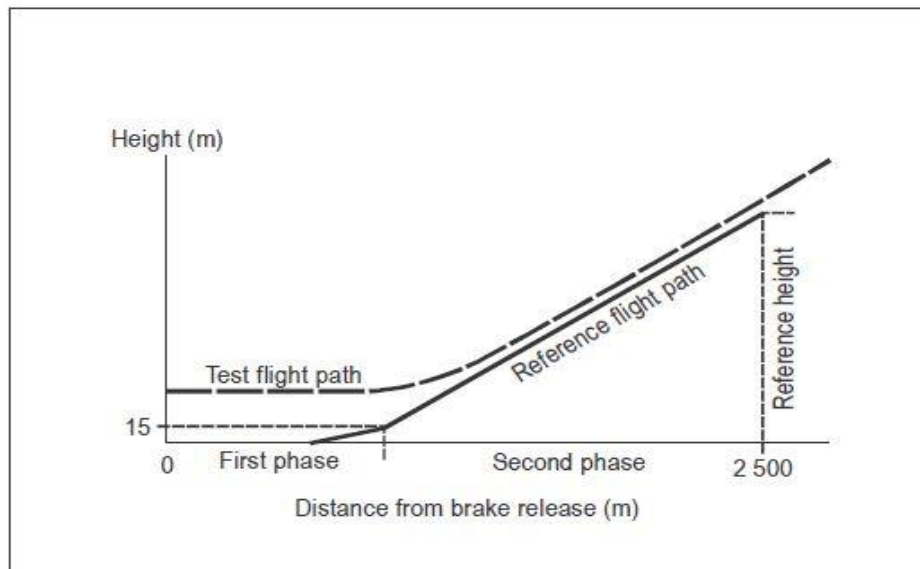


Figure A6-1. Typical test and reference profiles

4. MEASUREMENT OF AEROPLANE NOISE RECEIVED ON THE GROUND

4.1 General

- 4.1.1 All measuring equipment should be approved by the certifying authority.
- 4.1.2 Sound pressure level data for noise evaluation purposes should be obtained with acoustical equipment and measurement practices that conform to the specifications given hereunder in 4.2.

4.2 Measurement system

The acoustical measurement system should consist of approved equipment equivalent to the following:

- a) a microphone system designed to have mostly-uniform frequency response for sound incident on the diaphragm from random directions, or in the pressure field of a closed cavity, with performance characteristics meeting the requirements of 4.3;
- b) microphone installation and mounting hardware that minimizes interference with the sound being measured, in the configuration specified in 4.4;
- c) recording and reproducing equipment performance characteristics meeting the requirements of 4.3; and
- d) sound calibrators using sine wave signals of known sound pressure level meeting the requirements of 4.3.

4.3 Sensing, recording and reproducing equipment

4.3.1 The sound level produced by the aeroplane should be recorded. A magnetic tape recorder, graphic level recorder or sound level meter is acceptable at the option of the certifying authority.

4.3.2 The characteristics of the complete system with regard to directional response, frequency weighting A, time weighting S (slow), level linearity, and response to short-duration signals should comply with the class 1 specifications given in the IEC Publication 61672-1.¹ The complete system may include tape recorders according to IEC 61672-1. The certifying authority may approve the use of equipment compliant with class 2 of the current IEC standard, or the use of equipment compliant with class 1 or Type 1 specifications of earlier standards, as an alternative to equipment compliant with class 1 of the current IEC standard, if the applicant can show that the equipment had previously been approved for noise certification use by a certifying authority. The certifying authority may also approve the use of magnetic tape recorders that comply with the specifications of the older IEC 561 standard if the applicant can show that such use had previously been approved for noise certification use by a certifying authority.

4.3.3 The overall sensitivity of the measurement system should be checked before the start of testing, after testing has ended, and at intervals during testing using a sound calibrator generating a known sound pressure level at a known frequency. The sound

calibrator should conform to the class 1 requirements of IEC 60942.² The output of the sound calibrator should have been checked by a standardizing laboratory within 6 months of each aircraft noise measurement. Tolerable changes in output should be not more than 0.2 dB. Measured aircraft noise data should not be considered valid for certification purposes unless preceded and succeeded by valid sound pressure level calibrations. The measurement system should be considered satisfactory if the difference between the acoustical sensitivity levels recorded immediately before and immediately after each group of aircraft noise measurements on a given day is not greater than 0.5 dB. The certificating authority may approve the use of calibrators compliant with class 2 of the current IEC standard, or the use of calibrators compliant with class 1 of an earlier standard, if the applicant can show that the calibrator had previously been approved for noise certification use by a certificating authority.

4.3.4 When the sound from the aeroplane is tape recorded, the maximum A-frequency-weighted and S-time-weighted sound level may be determined by playback of the recorded signals into the electrical input facility of an approved sound level meter that conforms to the class 1 performance requirements of IEC 61672-1.¹ The acoustical sensitivity of the sound level meter should be established from playback of the associated recording of the signal from the sound calibrator and knowledge of the sound pressure level produced in the coupler of the sound calibrator under the environmental conditions prevailing at the time of the recording of the sound from the aeroplane.

4.4 Noise measurement procedures

4.4.1 The microphone should be a 12.7 mm diameter pressure type, with its protective grid, mounted in an inverted position such that the microphone diaphragm is 7 mm above and parallel to a circular metal plate. This white-painted metal plate should be 40 cm in diameter and at least 2.5 mm thick, and should be placed horizontally and flush with the surrounding ground surface with no cavities below the plate. The microphone should be located three-quarters of the distance from the center to the edge along a radius normal to the line of flight of the test aeroplane.

4.4.2 If the noise signal is tape-recorded, the frequency response of the electrical system should be determined, during each test series, at a level within 10 dB of the full-scale reading used during the tests, utilizing random or pseudorandom pink

1. IEC 61672-1: 2002 entitled "Electroacoustics - Sound level meters - Part I: Specifications". This IEC publication may be obtained from the Bureau central de la Commission électrotechnique internationale, 3 rue de Varembe, Geneva, Switzerland.
2. IEC 60942: 2003 entitled "Electroacoustics - Sound calibrators". This IEC publication may be obtained from the Bureau central de la Commission électrotechnique internationale, 3 rue de Varembe, Geneva, Switzerland.

noise. The output of the noise generator should have been checked by an approved standards laboratory within six months of the test series, and tolerable changes in the relative output at each one-third octave band should be not more than 0.2 dB. Sufficient determinations should be made to ensure that the overall calibration of the system is known for each test.

- 4.4.3 Where a magnetic tape recorder forms part of the measuring chain, each reel of magnetic tape should carry 30 s of this electrical calibration signal at its beginning and end for this purpose. In addition, data obtained from tape-recorded signals should be accepted as reliable only if the level difference in the 10 kHz one-third octave band filtered levels of the two signals is not more than 0.75 dB.

Note. - Digital audio recorders compliant with class 1 performance specifications of IEC 61672-1¹⁰ typically do not exhibit substantial variation with time in frequency response or level sensitivity, therefore the pink noise testing described in 4.4.3 is not necessary for digital audio recorders. Design characteristics for digital audio recorders should be compliant with class 1 performance specifications of IEC 61672-1.³

- 4.4.4 The A-frequency-weighted sound level of the background noise, including ambient noise and electrical noise of the measurement systems, should be determined in the test area with the system gain set at levels which will be used for aeroplane noise measurements. If the maximum A-frequency-weighted and S-time-weighted sound level of the aeroplane does not exceed the A-frequency-weighted sound level of the background noise by at least 10 dB, a take-off measurement point nearer to the start of roll should be used and the results adjusted to the reference measurement point by an approved method.

5. ADJUSTMENT TO TEST RESULTS

- 5.1 When certification test conditions differ from the reference conditions, appropriate adjustments should be made to the measured noise data by the methods of this section.

5.2 Corrections and adjustments

- 5.2.1 The adjustments take account of the effects of:

- a) differences in atmospheric absorption between meteorological test conditions and reference conditions; b) differences in the noise path length between the actual aeroplane flight path and the reference flight path; c) the change in the helical tip Mach number between test and reference conditions; and
- d) the change in engine power between test and reference conditions.

- 5.2.2 The noise level under reference conditions (L_{Amax}) shall be obtained by adding increments for each of the above effects to the test day noise level (L_{Amax}).

$$L_{ASmaxR} = L_{ASmax} + \Delta_1 + \Delta_2 + \Delta_3 + \Delta_4$$

where

$\Delta(M)$ is the adjustment for the change in atmospheric absorption between test and reference conditions;

Δ_1 is the adjustment for noise path lengths;

Δ_2 is the adjustment for helical tip Mach number; and

Δ_3 is the adjustment for engine power.

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3. IEC 61672-1: 2002 entitled “Electroacoustics — Sound level meters — Part I: Specifications”. This IEC publication may be obtained from the Bureau central de la Commission électrotechnique internationale, 3 rue de Varembe, Geneva, Switzerland.

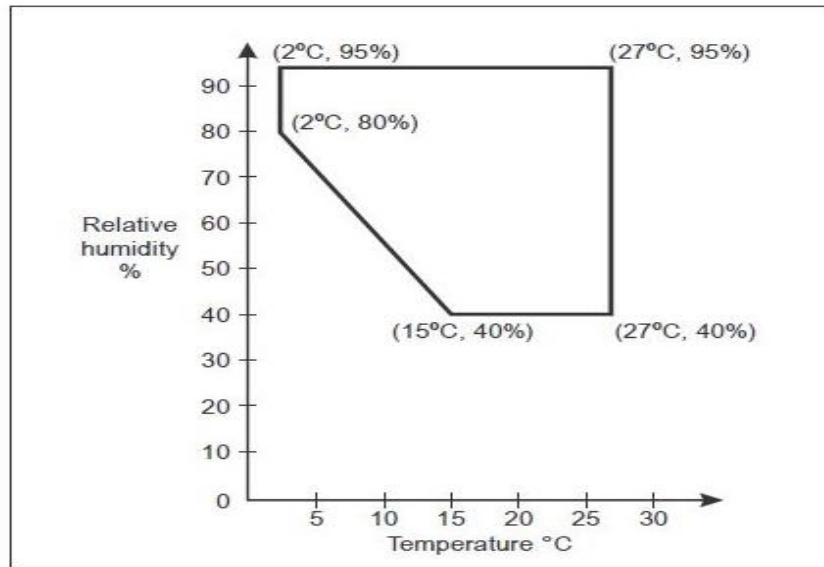


Figure A6-2. Measurement window for no absorption correction

- a) When the test conditions are within those specified in Figure A6-2, no adjustments for differences in atmospheric absorption need be applied, i.e. $(M) = 0$. If conditions are outside those specified in Figure A6-2 then adjustments

must be applied by an approved procedure or by adding an increment (M) to the test day noise levels where:

$$\Delta(M) = 0.01 (H_T \alpha - 0.2 H_R)$$

and where H_T is the height in metres of the test aeroplane when directly over the noise measurement point, H_R is the reference height of the aeroplane above the noise measurement point, and α is the rate of absorption at 500 Hz specified in Tables A1-5

- b) Measured noise levels should be adjusted to the height of the aeroplane over the noise measuring point on a reference day by algebraically adding an increment equal to Δ_1 . When test day conditions are within those specified in Figure A6-2:

$$\Delta_1 = 22 \log (H_T/H_R)$$

When test day conditions are outside those specified in Figure A6-2:

$$\Delta_1 = 20 \log (H_T/H_R)$$

where H_T is the height of the aeroplane when directly over the noise measurement point, and H_R is the reference height of the aeroplane over the measurement point.

- c) No adjustments for helical tip Mach number variations need be made if the propeller helical tip Mach number is:

- 1) at or below 0.70 and the test helical tip Mach number is within 0.014 of the

reference helical tip Mach number;

- 2) above 0.70 and at or below 0.80 and the test helical tip Mach number is within 0.007 of the reference helical tip Mach number;
- 3) above 0.80 and the test helical tip Mach number is within 0.005 of the reference helical tip Mach number. For mechanical tachometers, if the helical tip Mach number is above 0.8 and the test helical tip Mach number is within 0.008 of the reference helical tip Mach number.

Outside these limits measured noise levels should be adjusted for helical tip Mach number by an increment equal to:

$$\Delta_2 = K_2 \log (M_R/M_T)$$

Which should be added algebraically to the measured noise level, where M_T and M_R are the test and reference helical tip Mach numbers respectively. The value of K_2 should be determined from approved data from the test aeroplane. In the absence of flight test data and at the discretion of the certifying authority a value of $K_2 = 150$ may be used for M_T less than M_R ; however, for M_T greater than or equal to M_R no correction is applied.

Note.- The reference helical tip Mach number M_R is the one corresponding to the reference conditions above the measurement point:

Where

$$M_{HR} = \frac{\left[\left(\frac{D\pi N}{60} \right)^2 + V_R^2 \right]^{1/2}}{C_{HR}}$$


where D is the propeller diameter in metres.

V_R is the true airspeed of the aeroplane in reference conditions in metres per second.

N is the propeller speed in reference conditions in rpm. If N is not available, its value can be taken as the average of the propeller speeds over nominally identical power conditions during the flight tests.

C_{HR} is the reference day speed of sound at the altitude of the aeroplane in metres per second corresponding to the ambient temperature – assuming a lapse rate of 0.65°C per 100 m – for a standard day at the aeroplane reference height above mean sea level.

- d) Measured sound levels should be adjusted for engine power by algebraically adding an increment equal to:

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$$\Delta_3 = K_3 \log (P_R/P_T)$$

Where P and P_R are the test and reference engine powers respectively obtained from the manifold pressure/torque gauges and engine rpm. The value of K₃ should be determined from approved data from the test aeroplane. In the absence of flight test data and at the discretion of the certifying authority a value of K₃ = 17 may be used. The reference power P_R should be that obtained at the reference height pressure and temperature assuming an ISA temperature lapse rate with height.

6. REPORTING OF DATA TO THE CERTIFYING AUTHORITY AND VALIDITY OF RESULTS

6.1 Data reporting

6.1.1 Measured and corrected sound pressure levels obtained with equipment conforming to the specifications described in Section 4 of this appendix should be reported.

6.1.2 The type of equipment used for measurement and analysis of all acoustic aeroplane performance and meteorological data should be reported.

6.1.3 The following atmospheric environmental data, measured immediately before, after, or during each test at the observation points prescribed in Section 2 of this appendix should be reported:

- a) air temperature and relative humidity;
- b) wind speeds and wind directions; and
- c) atmospheric pressure.

6.1.4 Comments on local topography, ground cover and events that might interfere with sound recordings should be reported.

6.1.5 The following aeroplane information should be reported:

- a) type, model and serial numbers of aeroplane, engine(s) and propeller(s);
- b) any modifications or non-standard equipment likely to affect the noise characteristics of the aeroplane;
- c) maximum certificated take-off mass;
- d) for each overflight, airspeed and air temperature at the flyover altitude determined by properly calibrated instruments;
- e) for each overflight, engine performance as manifold pressure or power, propeller speed in revolutions per minute and other relevant parameters determined by properly calibrated instruments;
- f) aeroplane height above the measurement point; and

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- g) corresponding manufacturer’s data for the reference conditions relevant to 6.1.5 d), e) and f).

6.2 Validity of results

6.2.1 The measuring point should be overflowed at least six times. The test results should produce an average noise level (L_{Amax}) value and its 90 per cent confidence limits, the noise level being the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point.

6.2.2 The samples should be large enough to establish statistically a 90 per cent confidence limit not exceeding ± 1.5 dB(A). No test results should be omitted from the averaging process, unless otherwise specified by the certificating authority.

ATTACHMENTS TO PART 16, VOLUME I

ATTACHMENT A. EQUATIONS FOR THE CALCULATION OF MAXIMUM PERMITTED NOISE LEVELS AS A FUNCTION OF TAKE-OFF MASS

Note.— See Part II, 2.4.1, 2.4.2, 3.4.1, 4.4, 5.4, 6.3, 8.4.1, 8.4.2, 10.4, 11.4.1, 11.4.2, 13.4 and 14.4.1.

1. CONDITIONS DESCRIBED IN CHAPTER 2, 2.4.1

M = Maximum take-off

mass in 1000 kg 0 34 272

Lateral noise level (EPNdB)	102	$91.83 + 6.64 \log M$	108
Approach noise level (EPNdB)	102	$91.83 + 6.64 \log M$	108
Flyover noise level (EPNdB)	93	$67.56 + 16.61 \log M$	108

2. CONDITIONS DESCRIBED IN CHAPTER 2, 2.4.2

M = Maximum take-off

mass in 1 000 kg 0 34 35 48.3 66.72 133.45 280 325 400

Lateral noise level (EPNdB) All aeroplanes	97	$83.87 + 8.51 \log M$		106	
Approach noise level (EPNdB) All aeroplanes	101	$89.03 + 7.75 \log M$		108	
Flyover noise levels (EPNdB)	2 engines	93	$70.62 + 13.29 \log M$		104
	3 engines	93	$67.56 + 16.61 \log M$	$73.62 + 13.29 \log M$	107
	4 engines	93	$67.56 + 16.61 \log M$	$74.62 + 13.29 \log M$	108

3. CONDITIONS DESCRIBED IN CHAPTER 3, 3.4.1

M = Maximum take-off

mass in 1 000 kg 0 20.2 28.6 35 48.1 280 385 400

Lateral full-power noise level (EPNdB) All aeroplanes	94	$80.87 + 8.51 \log M$		103	
Approach noise level (EPNdB) All aeroplanes	98	$86.03 + 7.75 \log M$		105	
Flyover noise levels (EPNdB)	2 engines or less	89	$66.65 + 13.29 \log M$		101
	3 engines	89	$69.65 + 13.29 \log M$		104
	4 engines or more	89	$71.65 + 13.29 \log M$		106

4. CONDITIONS DESCRIBED IN CHAPTER 4, 4.4

Each of the following conditions should apply:

$$EPNL_L \leq LIMIT_L; EPNL_A \leq LIMIT_A; \text{ and } EPNL_F \leq LIMIT_F;$$

$$[(LIMIT_L - EPNL_L) + (LIMIT_A - EPNL_A) + (LIMIT_F - EPNL_F)] \geq 10$$

$$[(LIMIT_L - EPNL_L) + (LIMIT_A - EPNL_A)] \geq 2; [(LIMIT_L - EPNL_L) + (LIMIT_F - EPNL_F)] \geq 2; \text{ and}$$

$$[(LIMIT_A - EPNL_A) + (LIMIT_F - EPNL_F)] \geq 2$$

where

EPNL_L, EPNL_A and EPNL_F are, respectively, the noise levels at the lateral, approach and flyover reference noise measurement points when determined, to one decimal place, in accordance with the noise evaluation method of Appendix 2; and

LIMIT_L, LIMIT_A and LIMIT_F are, respectively, the maximum permitted noise levels at the lateral, approach and flyover reference noise measurement points determined, to one decimal place, in accordance with the equations for the conditions described in Chapter 3, 3.4.1 (Condition 3).

5 CONDITIONS DESCRIBED IN CHAPTER 5, 5.4

M = Maximum take-off

mass in 1000 kg	5.7	34.0	358.9	384.7
Lateral noise level (EPNdB)	96	85.83 + 6.64 log M		103
Approach noise level (EPNdB)	98	87.83 + 6.64 log M		105
Flyover noise level (EPNdB)	89	63.56 + 16.61 log M		106

6. CONDITIONS DESCRIBED IN CHAPTER 6, 6.3

M = Maximum take-off

mass in 1000 kg	0	0.6	1.5	8.618
Noise level in dB(A)	68	60 + 13.33 M		80

7. CONDITIONS DESCRIBED IN CHAPTER 8, 8.4.1, AND CHAPTER 13, 13.4

M = Maximum take-off

mass in 1000 kg	0	0.788	80.0
Take-off noise level (EPNdB)	89	$90.03 + 9.97 \log M$	109
Approach noise level (EPNdB)	90	$91.03 + 9.97 \log M$	110
Overflight noise level (EPNdB)	88	$89.03 + 9.97 \log M$	108

8. CONDITIONS DESCRIBED IN CHAPTER 8, 8.4.2

M = Maximum take-off

mass in 1000 kg	0	0.788	80.0
Take-off noise level (EPNdB)	86	$87.03 + 9.97 \log M$	106
Approach noise level (EPNdB)	89	$90.03 + 9.97 \log M$	109
Overflight noise level (EPNdB)	84	$85.03 + 9.97 \log M$	104

9. CONDITIONS DESCRIBED IN CHAPTER 10, 10.4 A) AND 10.4 B)

10.4 a):

M = Maximum take-off

mass in 1000 kg	0	0.6	1.4	8.618
Noise level in dB(A)	76	$83.23 + 32.67 \log M$	88	—

10.4 b):

M = Maximum take-off

mass in 1000 kg	0	0.57	1.5	8.618
Noise level in dB(A)	70	$78.71 + 35.70 \log M$	85	

10. CONDITIONS DESCRIBED IN CHAPTER 11, 11.4.1

M = Maximum take-off

mass in 1000 kg	0	1.417	3.175
Noise level in dB(A)	82	$80.49 + 9.97 \log M$	

11. CONDITIONS DESCRIBED IN CHAPTER 11, 11.4.2

M = Maximum take-off

mass in 1000 kg	0	1.417	3.175
Noise level in dB(A)	82	$80.49 + 9.97 \log M$	

12. CONDITIONS DESCRIBED IN CHAPTER 14, 14.4.1

M = Maximum take-off
mass in 1 000 kg

	0	2	8.618	20.234	28.615	35	48.125	280	385	400	
Lateral full-power noise level (EPNdB) All aeroplanes	88.6	$86.03754 + 8.512295 \log M$				94	$80.86511 + 8.50668 \log M$				103
Approach noise level (EPNdB) All aeroplanes	93.1	$90.77481 + 7.72412 \log M$				98	$86.03167 + 7.75117 \log M$		105		
Flyover noise levels (EPNdB)	2 engines or less	$76.57059 + 13.28771 \log M$				89		$66.64514 + 13.28771 \log M$		101	
	3 engines					80.6	89		$69.64514 + 13.28771 \log M$		104
	4 engines or more					89		$71.64514 + 13.28771 \log M$		106	

Note. The slope of the limit lines in the lower and higher weight regions are essentially the same. The observed minor differences between the coefficients of the equations defining the slopes of the lateral and approach lines are a consequence of the limits in Chapter 14, Sections 14.4.1.1 and 14.4.1.3, being defined with fixed end-points. For all practical purposes the minor differences between the coefficients are considered to be insignificant.


Each of the following conditions apply:

$$(LIMIT_L - EPNL_L) \geq 1; (LIMIT_A - EPNL_A) \geq 1; \text{ and } (LIMIT_F - EPNL_F) \geq 1;$$

$$[(LIMIT_L - EPNL_L) + (LIMIT_A - EPNL_A) + (LIMIT_F - EPNL_F)] \geq 17$$

where

EPNL_L, EPNL_A and EPNL_F are respectively the noise levels at the lateral, approach and flyover reference noise measurement points when determined, to one decimal place, in accordance with the noise evaluation method of Appendix 2; and LIMIT_L, LIMIT_A, and LIMIT_F are respectively the maximum permitted noise levels at the lateral, approach and flyover reference noise measurement points determined, to one decimal place, in accordance with the equations for the conditions described in Chapter 14, 14.4.1.

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ATTACHMENT B. GUIDELINES FOR NOISE CERTIFICATION OF PROPELLER-DRIVEN STOL AEROPLANES

Note.- See Part II, Chapter 7.

Note 1.- For the purpose of these guidelines, STOL aeroplanes are those which, when operating in the short take-off and landing mode, consistent with the relevant airworthiness requirements, require a runway length (with no stopway or clearway) of not more than 610 m at maximum certificated mass for airworthiness.

Note 2.- These guidelines are not applicable to aircraft with vertical take-off and landing capabilities.

1. APPLICABILITY

The following guidelines should be applied to all propeller-driven aeroplanes of over 5700 kg maximum certificated take-off mass intended for operation in the short take-off and landing (STOL) mode, requiring a runway¹ length, compatible with the relevant take-off and landing distance requirements, of less than 610 m at maximum certificated mass for airworthiness, and for which a certificate of airworthiness for the individual aeroplane was first issued on or after 1 January 1976.

2. NOISE EVALUATION MEASURE

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2 to this Part.

3. NOISE MEASUREMENT REFERENCE POINTS

The aeroplane, when tested in accordance with the flight test procedure of Section 6, should not exceed the noise levels specified in Section 4 at the following reference points:

- a) *lateral noise reference point:* the point on a line parallel to and 300 m from the runway center line, or extended runway center line, where the noise level is a maximum during take-off or landing, with the aeroplane operating in the STOL mode;
- b) *flyover noise reference point:* the point on the extended center line of the runway 1500 m from the start of the take-off roll; and
- c) *approach noise reference point:* the point on the extended center line of the runway 900 m from the runway threshold.

1. With no stopway or clearway.

4. MAXIMUM NOISE LEVELS

The maximum noise level at any of the reference points, when determined in accordance with the noise evaluation method of Appendix 2, should not exceed 96

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EPNdB in the case of aeroplanes with maximum certificated mass of 17000 kg or less, this limit increasing linearly with the logarithm of mass at a rate of 2 EPNdB per doubling of mass in the case of aeroplanes having maximum certificated mass in excess of 17000 kg.

5. TRADE-OFFS

If the maximum noise levels are exceeded at one or two measurement points:

- a) the sum of any excesses should not be greater than 4 EPNdB;
- b) any excess at any single point should not be greater than 3 EPNdB; and
- c) any excesses should be offset by a corresponding reduction at the other point or points.

6. TEST PROCEDURES

6.1 The take-off reference procedure should be as follows:

- a) the aeroplane should be at the maximum take-off mass for which noise certification is requested;
- b) the propeller and/or engine speed (rpm) and engine power setting scheduled for STOL take-off should be used; and
- c) throughout the take-off noise certification demonstration test, the airspeed, climb gradient, aeroplane attitude and aeroplane configuration should be those specified in the flight manual for take-off in the STOL mode.

6.2 The approach reference procedure should be as follows:

- a) the aeroplane should be at the maximum landing mass for which the noise certification is requested;
- b) throughout the approach noise certification demonstration test, the propeller and/or engine speed (rpm), engine power setting, airspeed, descent gradient, aeroplane attitude and aeroplane configuration should be those specified in the flight manual for STOL landing; and
- c) the use of reverse thrust after landing should be the maximum specified in the flight manual.

7. ADDITIONAL NOISE DATA

Where so specified by the certifying authority, data permitting measured noise levels

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to be evaluated in terms of the A-weighted overall sound pressure level (dB(A)) should be provided.

ATTACHMENT C. GUIDELINES FOR NOISE CERTIFICATION OF INSTALLED AUXILIARY POWER UNITS (APU) AND ASSOCIATED AIRCRAFT SYSTEMS DURING GROUND OPERATION

Note.- See Part II, Chapter 9.

1. INTRODUCTION

- 1.1 The following guidance material has been prepared for the information of States establishing noise certification requirements for installed auxiliary power units (APU) and associated aircraft systems used during normal ground operation.
- 1.2 It should apply to installed APU and associated aircraft systems in all aircraft for which the application for a Type Certificate, or another equivalent prescribed procedure, is submitted on or after 26 November 1981.
- 1.3 For aircraft of existing type design, for which the application for a change of type design involving the basic APU installation, or another equivalent prescribed procedure, is made on or after 26 November 1981, the noise levels produced by installed APU and associated aircraft systems should not exceed those existing prior to the change, when determined in accordance with the following guidelines.

2. NOISE EVALUATION PROCEDURE

The noise evaluation procedure should be according to the methods specified in Section 4.

3. MAXIMUM NOISE LEVELS

The maximum noise levels, when determined in accordance with the noise evaluation procedure specified in Section 4, should not exceed the following:

- a) 85 dB(A) at the points specified in 4.4.2.2 a), b) and c);
- b) 90 dB(A) at any point on the perimeter of the rectangle shown in Figure C-2.

4. NOISE EVALUATION PROCEDURES

4.1 General

- 4.1.1 Test procedures are described for measuring noise at specific locations (passenger and cargo doors, and servicing positions) and for conducting general noise surveys around aircraft.
- 4.1.2 Requirements are identified with respect to instrumentation, acoustic and atmospheric environment data acquisition, reduction and presentation, and such other information as is needed for reporting the results.

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4.1.3 Procedures involve recording data on magnetic tape for subsequent processing. The use of tape-recorder time-integrating analyser systems avoids the need to average by eye the variations associated with manual readings from sound level meters and octave band analysers and therefore yields more accurate results.

4.1.4 No provision is made for predicting APU noise from basic engine characteristics, nor for measuring noise of more than one aircraft operating at the same time.

4.2 General test conditions

4.2.1 Meteorological conditions

Wind: not more than 5.1 m/s (10 kt).

Note.- The noise certification test windows for wind speed expressed in m/s are the result of converting historically used values expressed in knots using a conversion factor consistent with Part 5, Chapter 3, Table 3-3, and rounded to 0.1 m/s. The values as given here, expressed in either unit, are considered equivalent for establishing adherence to the wind speed test windows for noise certification purposes.

Temperature: not less than 2°C nor more than 35°C.

Humidity: relative humidity not less than 30 per cent nor more than 90 per cent.

Precipitation: none.

Barometric pressure: not less than 800 hPa nor more than 1100 hPa.

4.2.2 Test site

The ground between microphone and aircraft should be a smooth, hard surface. No obstructions should be present between aircraft and measurement positions and no reflecting surfaces (except the ground and aircraft) should be near enough to sound paths to significantly influence results. Surface of the ground surrounding the aircraft should be sensibly flat and level at least over an area formed by boundaries parallel to and 60 m beyond the outermost microphone array identified in 4.4.2.2 d).

4.2.3 Ambient noise

Ambient noise of the measurement system and test area (that is, composite of the noise due to environmental background and the electrical noise of the acoustic instrumentation) should be determined.

4.2.4 APU installation

Pertinent APU and associated aircraft systems should be tested for each aircraft model for which acoustic data are required.

4.2.5 Aircraft ground configuration

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Aircraft flight control surfaces should be in the “neutral” or “clean” configuration, with gust locks on, or as stated in the aircraft’s approved operating manual for aircraft undergoing servicing.

4.3 Instrumentation

4.3.1 Aircraft

Operational data identified in 4.5.4 should be determined from normal aircraft instruments and controls.

4.3.2 Acoustical

4.3.2.1 General

Instrumentation and measurement procedures should be consistent with requirements of latest applicable issues of appropriate Standards listed in the references (see 4.6). All data samples should be at least 2.5 times the data reduction integration period which in no case should be less than 8 s. All sound pressure levels should be in decibels to a reference pressure of 20 μ Pa.

4.3.2.2 Data acquisition systems

Instrumentation systems for recording and analysis of noise, shown in the block diagram of Figure C-1, should meet the following specifications:


4.3.2.2.1 Microphone system

- a) over a frequency range of at least 45 Hz to 11200 Hz the system should meet the requirements as outlined under microphone system specifications in the latest issue of reference 10 (see 4.6);
- b) microphones should be omnidirectional, vented for pressure equalization if of condenser type, and should have known ambient pressure and temperature coefficients. Microphone amplifier specifications should be compatible with those of the microphone and tape recorder; and
- c) microphone windscreens should be employed when wind speed is in excess of 3 m/s (6 kt). Corrections as a function of frequency should be applied to measured data to account for the presence of microphone windscreens.

4.3.2.2.2 Tape recorder

The tape recorder may be direct record or FM and should have the following characteristics:

- a) dynamic range of 50 dB minimum in the octave or one-third octave bands;
- b) tape speed accuracy within ± 0.2 per cent of rated speed;

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- c) wow and flutter (peak to peak) less than 0.5 per cent of tape speed;
- d) maximum third harmonic distortion less than 2 per cent.

4.3.2.3 Calibration

4.3.2.3.1 Microphone

Frequency response calibration should be performed prior to the test series and a subsequent post- calibration should be performed within one month of the pre-calibration, with additional calibrations made when shock or damage is suspected.

Response calibration should cover the range of at least 45 Hz to 11200 Hz. Pressure response characteristics of the microphone should be corrected to obtain random incidence calibration.

4.3.2.3.2 Recording system

- a) A calibration tape, a recording of broadband noise or a sweep of sinusoidal signals over a minimum frequency range of 45 Hz to 11200 Hz should be recorded in the field or in the laboratory at the beginning and end of each test. The tape should also include signals at the frequencies employed during sound pressure sensitivity checks as defined below.
- b) This calibration signal, an insert voltage, should be applied to the input and should include all signal conditioning preamplifiers, networks and recorder electronics used to record acoustic data. In addition, a “shorted input” (i.e. microphone pressure sensitive element replaced with equivalent electrical impedance) recording of at least 20 s should be made as a check on system dynamic range and noise floor.
- c) Sound pressure sensitivity calibrations with the arrangements shown in Figure C-1 should be made in the field for each microphone prior to beginning and after completion of measurements each day. These calibrations should be made using a calibrator producing a known and constant-amplitude sound pressure level at one or more one-third octave band center frequencies, specified in reference 11 in the frequency range from 45 Hz to 11200 Hz. A barometric correction should be applied as required. Calibrators employed should be precise at least to within ± 0.5 dB and should have a calibration obtained according to references 6 to 9 (see 4.6).
- d) Each reel of tape should have comparable response and background noise to the calibration tape. A constant amplitude sine wave should be recorded at the start of each reel of tape, for reel-to-reel sound pressure sensitivity comparisons. The frequency of this sine wave should be within the same frequency range as used

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for sound pressure sensitivity checks. A separate voltage insert device or an acoustic calibrator may be used for this purpose. If an acoustic calibrator is used, it should be carefully “seated” and corrections for ambient pressure should be made so that effects of pressure on calibrator and microphone response are eliminated.

- e) Battery-driven tape recorders should be checked at frequent intervals during a test to ensure good battery condition. Tape recorders should not be moved while recording is in progress unless it has been established that such movements will not change tape-recorder characteristics.

4.3.2.3.3 *Data reduction equipment*

Data reduction equipment should be calibrated with electrical signals of known amplitude either at a series of discrete frequencies or with broadband signals covering the frequency range of 45 Hz to 11200 Hz.

4.3.2.4 *Data reduction*

4.3.2.4.1 The data reduction system of Figure C-1 should provide one-third or one octave band sound pressure levels. Analyser filters should comply with requirements of reference 12 (Class II for octave band filters and Class III for one-third octave band filters). Analyser amplitude resolution should be no worse than 0.5 dB; dynamic range should be a minimum of 50 dB between full scale and the root-mean-square (rms) value of the analyser noise floor in the octave band with the highest noise floor; and amplitude response over the upper 40 dB range should be linear to within ± 0.5 dB.

4.3.2.4.2 Mean-square sound pressures should be time averaged by integration of the squared output of frequency band filters over an integration interval that should be no less than 8 s. All data should be processed within the frequency range from 45 Hz to 11200 Hz. Data should be corrected for all known or predictable errors, such as deviations of system frequency response from a flat response.

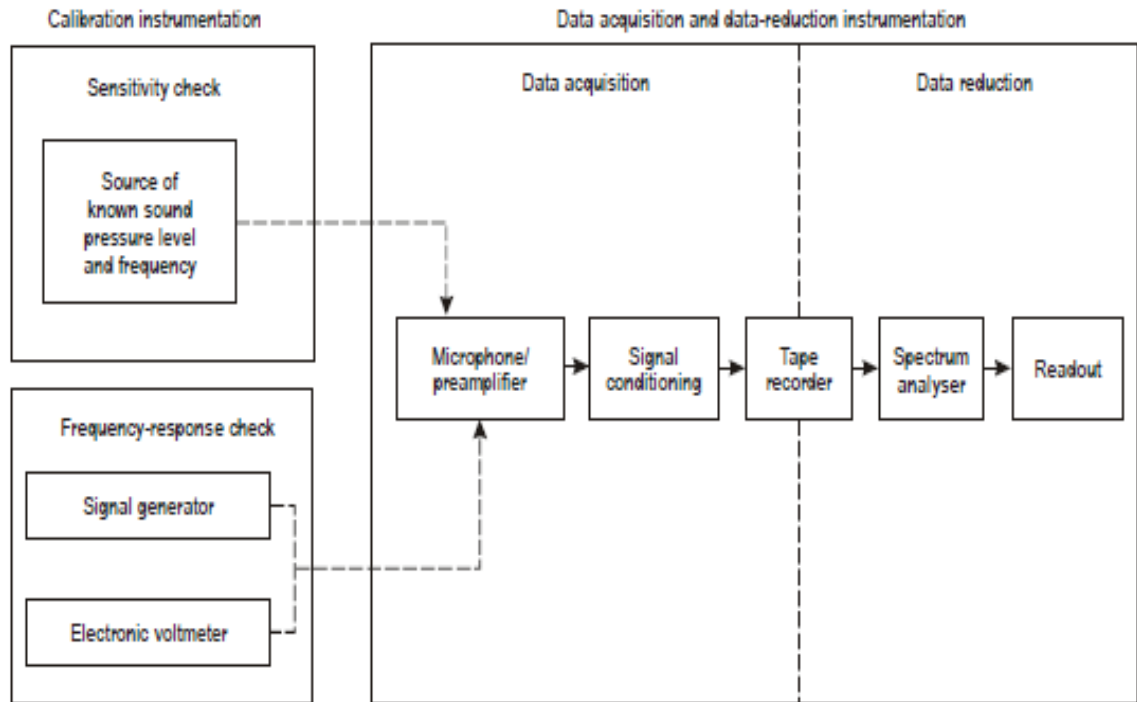


Figure C-1. Noise measurement systems

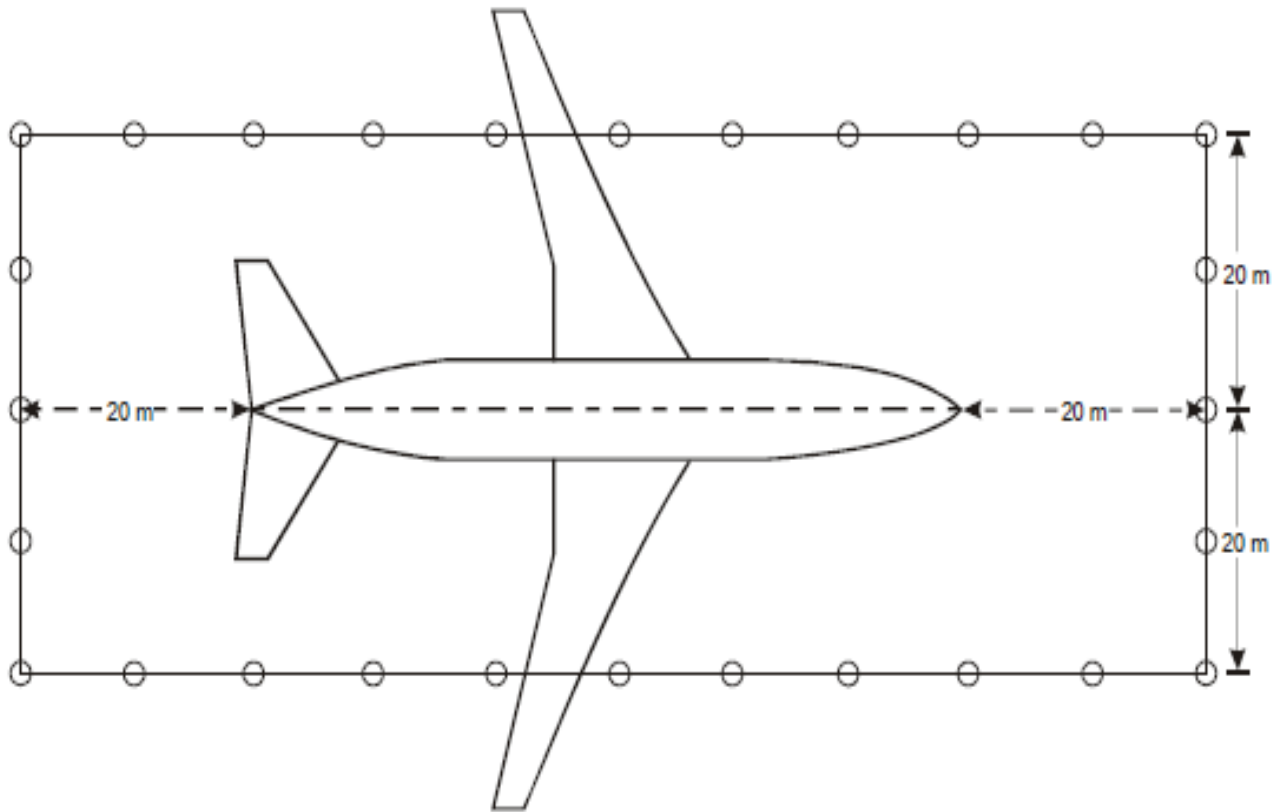


Figure C-2. Rectangle of noise survey measurement positions


4.3.2.5 Total system

4.3.2.5.1 In addition to specifications for component systems, frequency response of the combined data acquisition and reduction system should be flat within ± 3 dB over the frequency range from 45 Hz to 11200 Hz. Frequency response gradient anywhere within this range should not exceed 5 dB per octave.

4.3.2.5.2 Amplitude resolution should be at least 1.0 dB. Dynamic range should be a minimum of 45 dB between full scale and the rms value of the system noise floor in the frequency band with the highest noise floor. Amplitude response should be linear within ± 0.5 dB over the upper 35 dB in each frequency band.

4.3.3 Meteorological

The wind speed should be measured with a device having a range of at least 0 to 7.5 m/s (0 to 15 kt) with an accuracy of at least ± 0.5 m/s (± 1 kt). Temperature measurements should be made with a device having a range of at least 0°C to 40°C with an accuracy of at least $\pm 0.5^{\circ}\text{C}$. Relative humidity should be measured with a device having a range of 0 to 100 per cent with an accuracy of at least ± 5 percentage points.

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Atmospheric pressure should be measured with a device having a range of at least 800 to 1100 hPa with an accuracy of at least ± 3 hPa.

4.4 Test procedure

4.4.1 Test conditions

4.4.1.1 Ambient noise measurements should be made in sufficient number to be representative for all acoustic measurement stations, providing correction data to apply to measured APU noise where necessary (see 4.4.4).

4.4.1.2 The installed APU should meet the noise levels specified in 3.1 at the points specified under typical loads, up to and including those imposed by the electric power generator and air-conditioning units and any other associated systems at their normal maximum continuous ground operation power requirements.

Note.- A measurement of noise from a particular model of auxiliary power unit installed in a specific aircraft type should not be deemed typical of the same equipment installed in other aircraft types nor of other models of APU installed in the same aircraft type.

4.4.2 Acoustical measurement locations

4.4.2.1 Except where specified otherwise, noise measurements should be made with microphones at $1.6 \text{ m} \pm 0.025 \text{ m}$ ($5.25 \text{ ft} \pm 1.0 \text{ in}$) above the ground or surface where passengers or servicing personnel may stand, with the microphone diaphragm parallel to the ground and facing upwards.

4.4.2.2 Locations for measuring noise should be as follows:

- a) *cargo door locations*: measurements should be made at each cargo door location, with the door open, while the aircraft is in a typical ground handling configuration. These measurements should be taken at the center of the opening, in the plane of the fuselage skin;
- b) *passenger door locations*: measurements should be made at each passenger entry door, with the door open, on the vertical center line of the opening, in the plane of the fuselage skin;
- c) *servicing locations*: measurements should be made at all servicing positions where persons are normally working during aircraft ground handling operations, these positions to be determined by reference to the approved aircraft operating and service manuals;
- d) *survey locations*: appropriate measurement positions should be chosen along the sides of a rectangle centered on the test aircraft as illustrated in Figure C-2. The distance between measurement positions should not be greater than 10 m for large

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aircraft. This distance may be reduced to accommodate small aeroplanes or to fulfil special requirements.

4.4.3 Meteorological measurement locations

Meteorological data should be measured at a location at the test site within the microphone array of Figure C-2, but upwind of the aircraft and at a height of 1.6 m (5.25 ft) above ground level.

4.4.4 Data presentation

4.4.4.1 A-weighted sound levels should be calculated by applying frequency weighting corrections derived from the Standards for precision sound level meters (reference 10) to one-third or one octave band sound pressure levels. The one octave band sound pressure levels may be determined from a summation of mean-square sound pressures in appropriate one-third octave bands. Overall sound pressure levels should be determined from a summation of mean-square sound pressures in the 24 one-third octave, or 8 one octave, frequency bands included in the frequency range from 45 Hz to 11 200 Hz.

4.4.4.2 Overall sound pressure levels, A-weighted sound levels and one-third or one octave band data should be presented to the nearest decibel (dB) in tabular form, with supplementary graphical presentations as appropriate. Sound pressure levels should be corrected, if necessary, for the presence of high ambient noise. No corrections are needed if a sound pressure level is 10 dB or more above ambient noise. For sound pressure levels between 3 and 10 dB above ambient noise, measured values should be corrected for ambient noise by logarithmic subtraction of levels. If sound pressure levels do not exceed ambient noise by as much as 3 dB, the measured values may be adjusted by means of a method agreed to by the certificating authority.

4.4.4.3 Acoustical data need not be normalized for atmospheric absorption losses. Test results should be reported under the actual test-day meteorological conditions.

4.5 Data reporting

4.5.1 Identification information

- a) Test location, date and time of test.
- b) Manufacturer and model of the APU and pertinent associated equipment.
- c) Aircraft type, manufacturer, model and air registry number.
- d) Plan and elevation views, as appropriate, of the aircraft outline showing location of the APU (including inlet and exhaust ports), all associated equipment, and all acoustical measurement stations.

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4.5.2 Test site description

- a) Type and location of ground surfaces.
- b) Location and extent of any above-ground-level reflective surfaces, such as buildings or other aircraft, that might have been present in spite of the precautions noted in 4.2.2.

4.5.3 Meteorological data *(for each test condition)*

- a) Wind speed, m/s (kt) and direction, degrees, relative to aircraft center line (forward 0°).
- b) Ambient temperature °C.
- c) Relative humidity, per cent.
- d) Barometric pressure, hPa.

4.5.4 Operational data *(for each test condition)*

- a) Number of air-conditioning packs operated and their locations.
- b) APU shaft speed(s), rpm or percentage of normal rated.
- c) APU normal rated shaft speed, rpm.
- d) APU shaft load (kW), horsepower and/or electric power output, kVA.
- e) Pneumatic load, kg/min delivered by APU to all pneumatically operated aircraft systems during the test (calculated as required).
- f) Temperature of APU exhaust gas at location specified in aircraft's approved operations manual, °C.
- g) Operating mode of environmental control system, cooling or heating.
- h) Air-conditioning distribution system supply duct temperature, °C.
- i) Events occurring during the test which may have influenced the measurements.

4.5.5 Instrumentation

- a) A brief description (including manufacturer and type or model numbers) of the acoustical and meteorological measuring instruments.
- b) A brief description (including manufacturer and type or model numbers) of the data acquisition and data processing systems.

4.5.6 Acoustical data

- a) Ambient noise.

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- b) Acoustical data specified in 4.4.4 with a description of corresponding microphone locations.
- c) List of standards used and description and reason for any deviations.

4.6 References


Related standard for instruments and measurement procedures

1. *International Electrotechnical Vocabulary*, 2nd Edition, IEC-50(08) (1960).
2. *Acoustic Standard Tuning Frequency*, ISO-16.
3. *Expression of the Physical and Subjective Magnitudes of Sound or Noise*, ISO-131 (1959).
4. *Acoustics — Preferred Reference Quantities for Acoustic Levels*, ISO DIS 1638.2.
5. *Guide to the Measurement of Acoustical Noise and Evaluation of its Effects on Man*, ISO-2204 (1973).
6. *Precision Method for Pressure Calibration of One-inch Standard Condenser Microphone by the Reciprocity Technique*, IEC-327 (1971).
7. *Precision Method for Free Field Calibration of One-inch Standard Condenser Microphone by the Reciprocity Technique*, IEC-486 (1974).
8. *Values for the Difference between Free Field and Pressure Sensitivity Levels for One-inch Standard Condenser Microphone*, IEC-655 (1979).
9. *Simplified Method for Pressure Calibration of One-inch Standard Condenser Microphone by the Reciprocity Technique*, IEC-402 (1972).
10. *IEC Recommendations for Sound Level Meters*, International Electrotechnical Commission, IEC 651 (1979).
11. *ISO Recommendations for Preferred Frequencies for Acoustical Measurements*, International Organization for Standardization, ISO/R266-1962(E).
12. *IEC Recommendations for Octave, Half-Octave and Third-Octave Band Filters Intended for the Analysis of Sounds and Vibrations*, International Electrotechnical Commission, IEC 225 (1966).

Note.- The texts and specifications of these publications, as amended, are incorporated by reference into this attachment.

IEC publications may be obtained from:
 Central Office of the International Electrotechnical Commission
 3 rue de Varembe
 Geneva, Switzerland

ISO publications may be obtained from:

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International Organization for Standardization
1 rue de Varembe
Geneva, Switzerland
or from State ISO member bodies.

ATTACHMENT D. GUIDELINES FOR EVALUATING AN ALTERNATIVE METHOD OF MEASURING HELICOPTER NOISE DURING APPROACH

Note. - The approach reference procedure of Part II, Chapter 8, 8.6.4, specifies a single approach path angle. This can coincide with the impulsive noise regime for some helicopters and not for others. In order that alternative methods of establishing compliance may be evaluated, States are encouraged to undertake additional measurements as described below.

1. INTRODUCTION

The following guidance material has been prepared for the use of States when obtaining additional information on which a future revision of the approach test procedures of Chapter 8 may be based.

2. APPROACH NOISE EVALUATION PROCEDURE

When conducting such tests the provisions of Chapter 8 should be observed except as follows.

2.1 Approach reference noise measurement points

A flight path reference point located on the ground 120 m (394 ft) vertically below the flight paths defined in the approach reference procedure. On level ground this corresponds to the following positions:

- a) 2290 m from the intersection of the 3° approach path with the ground plane;
- b) 1140 m from the intersection of the 6° approach path with the ground plane;
- c) 760 m from the intersection of the 9° approach path with the ground plane.

2.2 Maximum noise levels

At the approach flight path reference point: the noise level to be calculated by taking the arithmetical average of the corrected levels for 3°, 6° and 9° approaches.

2.3 Approach reference procedure

The approach reference procedure should be established as follows:

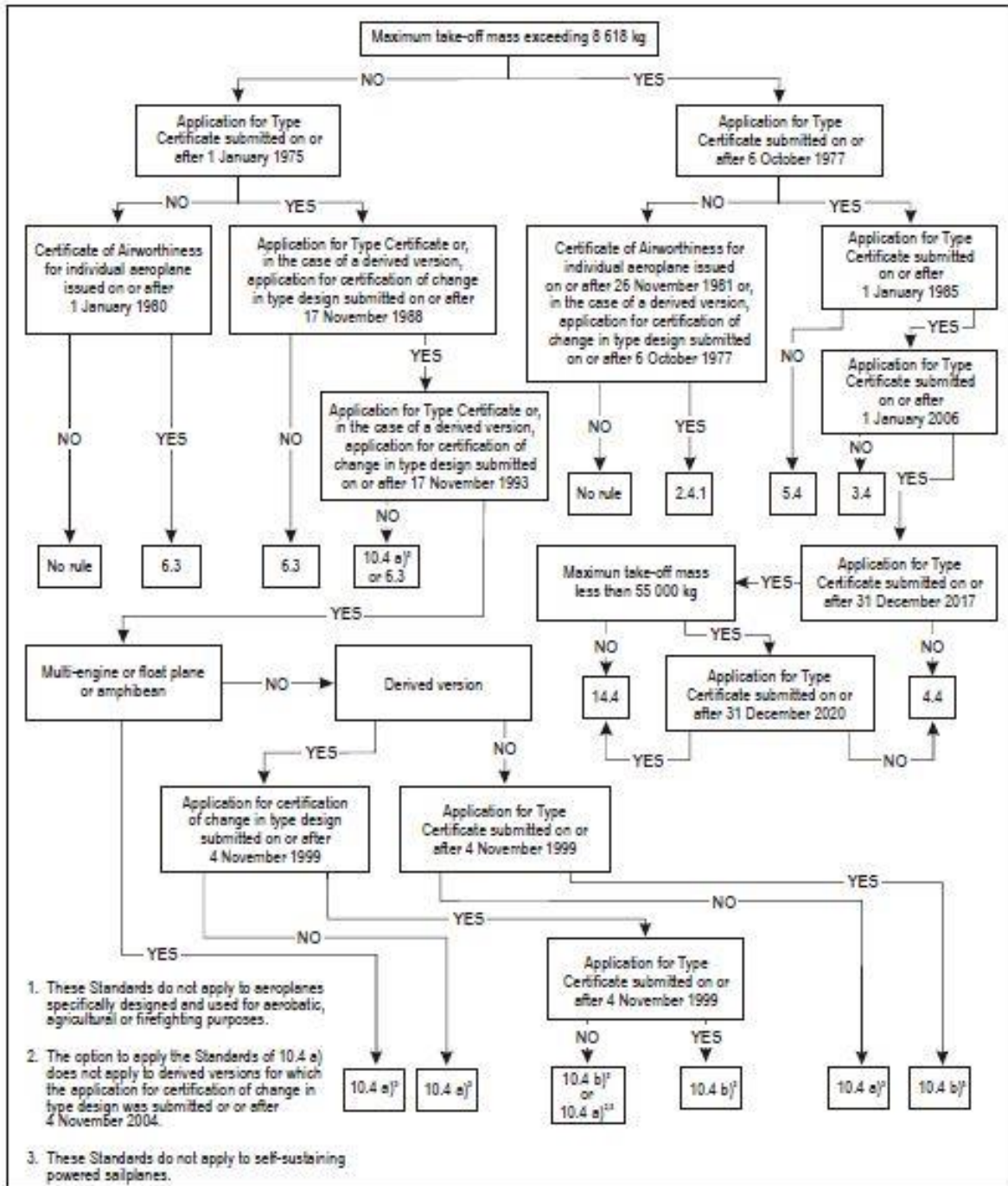
- a) the helicopter should be stabilized and following approach paths of 3°, 6° and 9°;
- b) the approach should be made at a stabilized airspeed equal to the best rate of climb speed, V_y , or the lowest approved speed for the approach, whichever is the greater, with power stabilized during the approach and over the flight path reference point, and continued to a normal touchdown;
- c) the approach should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests,


with the landing gear extended, should be maintained throughout the approach reference procedure; and

- e) the mass of the helicopter at touchdown should be the maximum landing mass at which noise certification is requested.



ATTACHMENT E. APPLICABILITY OF PART 16 NOISE CERTIFICATION STANDARDS FOR PROPELLER-DRIVEN AEROPLANES¹



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ATTACHMENT F. GUIDELINES FOR NOISE CERTIFICATION OF TILT-ROTORS

Note.- See Part II, Chapter 13.

Note 1.- These guidelines are applicable to heavier- than-air aircraft that can be supported in flight chiefly by the reactions of the air on two or more power-driven rotors on axes which can be changed from substantially vertical to horizontal.

Note 2.- These guidelines are not intended to be used for tilt-rotors that have one or more configurations that are certificated for airworthiness for STOL only. In such cases, different or additional guidelines would likely be needed.

1. APPLICABILITY

The following guidelines should be applied to all tilt-rotors, including their derived versions, for which the application for a Type Certificate was submitted on or after 13 May 1998 and before 1 January 2018.

Note.- Certification of tilt-rotors which are capable of carrying external loads or external equipment should be made without such loads or equipment fitted.

2. NOISE EVALUATION MEASURE

The noise evaluation measure should be the effective perceived noise level in EPNdB as described in Appendix 2 of this Part.


Note.- Additional data in L_{AE} and L_{Amax} as defined in Appendix 4, and one-third octave SPLs as defined in Appendix 2 corresponding to L_{Amax} should be made available to the certifying authority for land-use planning purposes.

3. NOISE MEASUREMENT REFERENCE POINTS

A tilt-rotor, when tested in accordance with the reference procedures of Section 6 and the test procedures of Section 7, should not exceed the noise levels specified in Section 4 at the following reference points:

- a) *Take-off reference noise measurement points:*
 - 1) a flight path reference point located on the ground vertically below the flight path defined in the take-off reference procedure (see 6.2) and 500 m horizontally in the direction of flight from the point at which transition to climbing flight is initiated in the reference procedure;
 - 2) two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the take-off reference procedure and lying on a line through the flight path reference point.
- b) *Overflight reference noise measurement points:*
 - 1) a flight path reference point located on the ground 150 m (492 ft) vertically below the flight path defined in the overflight reference procedure (see 6.3);

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- 2) two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the overflight reference procedure and lying on a line through the flight path reference point.
- c) *Approach reference noise measurement points:*
- 1) a flight path reference point located on the ground 120 m (394 ft) vertically below the flight path defined in the approach reference procedure (see 6.4). On level ground, this corresponds to a position 1140 m from the intersection of the 6.0 degree approach path with the ground plane;
 - 2) two other points on the ground symmetrically disposed at 150 m on both sides of the flight path defined in the approach reference procedure and lying on a line through the flight path reference point.

4. MAXIMUM NOISE LEVELS

For tilt-rotors specified in Section 1, the maximum noise levels, when determined in accordance with the noise evaluation method of Appendix 2 for helicopters, should not exceed the following:

- a) *At the take-off flight path reference point:* 109 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 89 EPNdB after which the limit is constant.
- b) *At the overflight path reference point:* 108 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 88 EPNdB after which the limit is constant.

Note 1.- For the tilt-rotor in aeroplane mode, there is no maximum noise level.

Note 2.- VTOL/conversion mode is all approved configurations and flight modes where the design operating rotor speed is that used for hover operations.

- c) *At the approach flight path reference point:* 110 EPNdB for tilt-rotors in VTOL/conversion mode with maximum certificated take-off mass, at which the noise certification is requested, of 80000 kg and over and decreasing linearly with the logarithm of the tilt-rotor mass at a rate of 3 EPNdB per halving of mass down to 90 EPNdB after which the limit is constant.

Note.- The equations for the calculation of noise levels as a function of take-off mass presented in Section 8 of Attachment A, for conditions described in Chapter 8, are consistent with the maximum noise levels defined in these guidelines.


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5. TRADE-OFFS

If the maximum noise levels are exceeded at one or two measurement points:

- a) the sum of excesses should not be greater than 4 EPNdB;
- b) any excess at any single point should not be greater than 3 EPNdB; and
- c) any excess should be offset by corresponding reductions at the other point or points.

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6. NOISE CERTIFICATION REFERENCE PROCEDURES

6.1 General conditions

- 6.1.1 The reference procedures should comply with the appropriate airworthiness requirements.
- 6.1.2 The reference procedures and flight paths should be approved by the certificating authority.
- 6.1.3 Except in conditions specified in 6.1.4, the take-off, overflight and approach reference procedures should be those defined in 6.2, 6.3 and 6.4, respectively.
- 6.1.4 When it is shown by the applicant that the design characteristics of the tilt-rotor would prevent a flight from being conducted in accordance with 6.2, 6.3 or 6.4, the reference procedures should:
- a) depart from the reference procedures defined in 6.2, 6.3 or 6.4 only to the extent demanded by those design characteristics which make compliance with the reference procedures impossible; and
 - b) be approved by the certificating authority.
- 6.1.5 The reference procedures should be established for the following reference atmospheric conditions:
- a) sea level atmospheric pressure of 1 013.25 hPa;
 - b) ambient air temperature of 25°C, i.e. ISA + 10°C;
 - c) relative humidity of 70 per cent; and
 - d) zero wind.
- 6.1.6 In 6.2 d), 6.3 d) and 6.4 c), the maximum normal operating rpm should be taken as the highest rotor speed for each reference procedure corresponding to the airworthiness limit imposed by the manufacturer and approved by the certificating authority. Where a tolerance on the highest rotor speed is specified, the maximum normal operating rotor speed should be taken as the highest rotor speed about which that tolerance is given. If the rotor speed is automatically linked with the flight condition, the maximum normal operating rotor speed corresponding with the reference flight condition should be used during the noise certification procedure. If the rotor speed can be changed by pilot action, the maximum normal operating rotor speed specified in the flight manual limitation section for the reference conditions should be used during the noise certification procedure.

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6.2 Take-off reference procedure


The take-off reference flight procedure should be established as follows:

- a) a constant take-off configuration, including nacelle angle, selected by the applicant should be maintained throughout the take-off reference procedure;
- b) the tilt-rotor should be stabilized at the maximum take-off power corresponding to minimum installed engine(s) specification power available for the reference ambient conditions or gearbox torque limit, whichever is lower, and along a path starting from a point located 500 m prior to the flight path reference point, at 20 m (65 ft) above the ground;
- c) the nacelle angle and the corresponding best rate of climb speed, or the lowest approved speed for the climb after take-off, whichever is the greater, should be maintained throughout the take-off reference procedure;
- d) the steady climb should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for take-off;
- e) the mass of the tilt-rotor should be the maximum take-off mass at which noise certification is requested; and
- f) the reference take-off path is defined as a straight line segment inclined from the starting point (500 m prior to the center noise measurement point and 20 m (65 ft) above ground level) at an angle defined by best rate of climb (BRC) and the best rate of climb speed corresponding to the selected nacelle angle and for minimum specification engine performance.

6.3 Overflight reference procedure

The overflight reference procedure should be established as follows:

- a) the tilt-rotor should be stabilized in level flight overhead the flight path reference point at a height of 150 m (492 ft);
- b) a constant configuration selected by the applicant should be maintained throughout the overflight reference procedures;
- c) the mass of the tilt-rotor should be the maximum take-off mass at which noise certification is requested;
- d) in the VTOL/conversion mode, the nacelle angle at the authorized fixed operation point that is closest to the lowest nacelle angle certificated for zero airspeed, a speed of $0.9V_{CON}$ and a rotor speed stabilized at the maximum normal operating

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rpm certificated for level flight should be maintained throughout the overflight reference procedure;

Note.- For noise certification purposes, V_{CON} is defined as the maximum authorized speed for VTOL/conversion mode at a specific nacelle angle.

- e) in the aeroplane mode, the nacelles should be maintained on the down-stop throughout the overflight reference procedure, with:
 - 1) rotor speed stabilized at the rpm associated with the VTOL/conversion mode and a speed of $0.9V_{CON}$; and
 - 2) rotor speed stabilized at the normal cruise rpm associated with the aeroplane mode and at the corresponding $0.9V_{MCP}$ or $0.9V_{MO}$, whichever is lesser, certificated for level flight.

Note 1.- For noise certification purposes, V_{MCP} is defined as the maximum operating limit airspeed for aeroplane mode corresponding to minimum engine installed, maximum continuous power (MCP) available for sea level pressure (1 013.25 hPa), 25°C ambient conditions at the relevant maximum certificated mass; and V_{MO} is the maximum operating (MO) limit airspeed that may not be deliberately exceeded.

Note 2.- The values of V_{CON} and V_{MCP} or V_{MO} used for noise certification should be quoted in the approved flight manual.

6.4 Approach reference procedure


The approach reference procedure should be established as follows:

- a) the tilt-rotor should be stabilized and follow a 6.0 degree approach path;
- b) the approach should be in an airworthiness-approved configuration in which maximum noise occurs, at a stabilized airspeed equal to the best rate of climb speed corresponding to the nacelle angle, or the lowest approved airspeed for the approach, whichever is the greater, and with power stabilized during the approach and over the flight path reference point, and continued to a normal touchdown;
- c) the approach should be made with the rotor speed stabilized at the maximum normal operating rpm certificated for approach;
- d) the constant approach configuration used in airworthiness certification tests, with the landing gear extended, should be maintained throughout the approach reference procedure; and
- e) the mass of the tilt-rotor at touchdown should be the maximum landing mass at which noise certification is requested.


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7. TEST PROCEDURES

- 7.1 The test procedures should be acceptable to the airworthiness and noise certificating authority of the State issuing the certificate.
- 7.2 The test procedures and noise measurements should be conducted and processed in an approved manner to yield the noise evaluation measure designated in Section 2.
- 7.3 Test conditions and procedures should be similar to reference conditions and procedures or the acoustic data should be adjusted, by the methods outlined in Appendix 2 for helicopters, to the reference conditions and procedures specified in this attachment.
- 7.4 Adjustments for differences between test and reference flight procedures should not exceed:
- a) *for take-off*: 4.0 EPNdB, of which the arithmetic sum of delta 1 and the term $-7.5 \log(QK/Q_rK_r)$ from delta 2 should not in total exceed 2.0 EPNdB; and
 - b) *for overflight or approach*: 2.0 EPNdB.
- 7.5 During the test the average rotor rpm should not vary from the normal maximum operating rpm by more than ± 1.0 per cent during the 10 dB-down time period.
- 7.6 The tilt-rotor airspeed should not vary from the reference airspeed appropriate to the flight demonstration by more than ± 9 km/h (5 kt) throughout the 10 dB-down time period.
- 7.7 The number of level overflights made with a headwind component should be equal to the number of level overflights made with a tailwind component.
- 7.8 The tilt-rotor should fly within ± 10 degrees or ± 20 m, whichever is greater, from the vertical above the reference track throughout the 10 dB-down time period (see Figure 8-1 of Part II, Chapter 8).
- 7.9 The tilt-rotor height should not vary during overflight from the reference height at the overhead point by more than ± 9 m (30 ft).
- 7.10 During the approach noise demonstration the tilt-rotor should be established on a stabilized constant speed approach within the airspace contained between approach angles of 5.5 degrees and 6.5 degrees.
- 7.11 Tests should be conducted at a tilt-rotor mass not less than 90 per cent of the relevant maximum certificated mass and may be conducted at a mass not exceeding 105 per

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cent of the relevant maximum certificated mass. For each of the flight conditions, at least one test must be completed at or above this maximum certificated mass.

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ATTACHMENT G. GUIDELINES FOR THE ADMINISTRATION OF NOISE CERTIFICATION DOCUMENTATION

Note.— See Part II, Chapter 1.

1. INTRODUCTION

The following information is provided for the benefit of States that wish to have further guidance on the administration of noise certification documentation. These guidelines are not intended to be applied retroactively, but if States wish to apply the proposed formats retroactively they are free to do so.

2. NOISE CERTIFICATION DOCUMENTATION

2.1 Information to be provided

2.1.1 Chapter 1, 1.5, specifies which information should, as a minimum, be included in the noise certification documentation. The following provides further guidance on these items. Note that all items must be numbered in accordance with 1.5 and 1.6 of Part II, Chapter 1, using Arabic numbers. This is to facilitate access to the information when the noise certification documentation is issued in a language foreign to the user of the information. Some items are relevant to certain chapters only. In these cases the relevant chapters are indicated in the item.

2.1.2 *Item 1. Name of State*

The name of the State issuing the noise certification documentation. This item should correspond with the information on the certificate of registration and the certificate of airworthiness.

2.1.3 *Item 2. Title of the noise document*


As explained in Section 2.3, several different kinds of documents can be issued depending on the administrative system for implementation of the noise certification documentation. The system chosen will determine the name of the document or documents, for instance “noise certificate”, “noise certification document” or any other title that the State of Registry uses in its administrative system.

2.1.4 *Item 3. Number of the document*

A unique number, issued by the State of Registry that identifies this particular document in its administration. Such a number will facilitate any enquiries with respect to the document.

2.1.5 *Item 4. Nationality or common mark and registration marks*

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The nationality or common mark and registration marks issued by the State of Registry in accordance with Part 7. This item should correspond with the information on the certificate of registration and the certificate of airworthiness.

2.1.6 *Item 5. Manufacturer and manufacturer’s designation of aircraft*

The type and model of the subject aircraft. This item should correspond with the information on the certificate of registration and the certificate of airworthiness.

2.1.7 *Item 6. Aircraft serial number*

The aircraft serial number as given by the manufacturer of the aircraft. This item should correspond with the information on the certificate of registration and the certificate of airworthiness.

2.1.8 *Item 7. Engine manufacturer, type and model*

The designation of the installed engine(s) for identification and verification of the aircraft configuration. It should contain the type and model of the subject engine(s) . The designation should be in accordance with the type certificate or supplemental type certificate for the subject engine(s).

2.1.9 *Item 8. Propeller type and model for propeller-driven aeroplanes*

The designation of the installed propeller(s) for identification and verification of the aircraft configuration. It should contain the type and model of the subject propeller(s). The designation should be in accordance with the type certificate or supplemental type certificate for the subject propeller(s). This item is included only in the noise certification documentation for propeller-driven aeroplanes.


2.1.10 *Item 9. Maximum take-off mass and unit*

The maximum take-off mass, in kilograms, associated with the certificated noise levels of the aircraft. The unit (kg) should be specified explicitly in order to avoid misunderstanding. If the primary unit of mass of the State of Design of the aircraft is different from kilograms, the conversion factor used should be in accordance with Part 5.

2.1.11 *Item 10. Maximum landing mass and unit for certificates issued under Chapters 2, 3, 4, 5, 12 and 14*

The maximum landing mass, in kilograms, associated with the certificated noise levels of the aircraft. The unit (kg) should be specified explicitly in order to avoid misunderstanding. If the primary unit of mass of the State of Design of the aircraft is

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different from kilograms, the conversion factor used should be in accordance with Part 5. This item is included only in the noise certification documentation for documents issued under Chapters 2, 3, 4, 5, 12 and 14.

- 2.1.12 *Item 11. The chapter and section of Part 16, Volume I, according to which the aircraft is certificated*

The chapter of Part 16, Volume I, to which the subject aircraft is noise certificated. For Chapters 2, 8, 10 and 11, the section specifying the noise limits should also be included.

- 2.1.13 *Item 12. Additional modifications incorporated for the purpose of compliance with the applicable noise certification Standards*

This item should contain, as a minimum, all additional modifications to the basic aircraft as defined by Items 5, 7 and 8 that are essential in order to meet the requirements of the chapter of Part 16, Volume I, to which the aircraft is noise certificated as given under Item 11. Other modifications that are not essential to meet the stated chapter but are needed to attain the certificated noise levels as given may also be included at the discretion of the certifying authority. The additional modifications should be given using unambiguous references, such as supplemental type certificate (STC) numbers, unique part numbers or type/model designators given by the manufacturer of the modification.

- 2.1.14 *Item 13. The lateral/full-power noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 12 and 14*

The lateral/full-power noise level as defined in the relevant chapter. It should specify the unit (e.g. EPNdB) of the noise level, and the noise level should be stated to the nearest tenth of a dB. This item is included only in the noise certification documentation for aircraft certificated to Chapters 2, 3, 4, 5, 12 and 14.


- 2.1.15 *Item 14. The approach noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 8, 12, 13 and 14*

The approach noise level as defined in the relevant chapter. It should specify the unit (e.g. EPNdB) of the noise level, and the noise level should be stated to the nearest tenth of a dB. This item is included only in the noise certification documentation for aircraft certificated to Chapters 2, 3, 4, 5, 8, 12, 13 and 14.

- 2.1.16 *Item 15. The flyover noise level in the corresponding unit for documents issued under Chapters 2, 3, 4, 5, 12 and 14*

The flyover noise level as defined in the relevant chapter. It should specify the unit (e.g. EPNdB) of the noise level, and the noise level should be stated to the nearest tenth of a dB. This item is included only in the noise certification documentation for aircraft

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certificated to Chapters 2, 3, 4, 5, 12 and 14.

2.1.17 *Item 16. The overflight noise level in the corresponding unit for documents issued under Chapters 6, 8, 11 and 13*

The overflight noise level as defined in the relevant chapter. It should specify the unit (e.g. EPNdB or dB(A)) of the noise level, and the noise level should be stated to the nearest tenth of a dB. This item is included only in the noise certification documentation for aircraft certificated to Chapters 6, 8, 11 and 13.

Note.- For tilt-rotors certificated according to Chapter 13 only the overflight noise level established in VTOL/conversion mode needs to be stated.

2.1.18 *Item 17. The take-off noise level in the corresponding unit for documents issued under Chapters 8, 10 and 13*

The take-off noise level as defined in the relevant chapter. It should specify the unit (e.g. EPNdB or dB(A)) of the noise level, and the noise level should be stated to the nearest tenth of a dB. This item is included only in the noise certification documentation for aircraft certificated to Chapters 8, 10 and 13.

2.1.19 *Item 18. Statement of compliance, including reference to Part 16, Volume I*

A statement that the subject aircraft complies with the applicable noise requirements. Reference should be made to Part 16, Volume I. In addition to this, reference may be made to national noise requirements.

2.1.20 *Item 19. Date of issuance of the noise certification document*

The date on which the noise certification document was issued.

2.1.21 *Item 20. Signature of the officer issuing it*

The signature of the officer issuing the noise certification document. Other items may be added such as a seal or a stamp.

2.2 Additional information

2.2.1 States may decide to add additional information to the noise certification documentation at their own discretion. Caution should be exercised to ensure that the information provided will not be confused with the official noise certification levels. In particular, noise levels taken under conditions other than the noise certification conditions should be clearly marked as supplementary information. The additional information should be placed in a “remarks” box or in separate boxes. These boxes should *not* be numbered in order to avoid non-standardized numbering and to allow for future modifications to the numbering system. The box or boxes should contain an

adequate description of what additional information is provided. Examples of possible additional information are provided in 2.2.2 through 2.2.7.

2.2.2 *Logo and name of the issuing authority*

In order to facilitate recognition, the logo or symbol and the name of the issuing authority may be added.

2.2.3 *Noise limits*

If added, noise limits should be given according to the subject noise requirements and should be quoted, to the nearest tenth of a decibel, in the appropriate unit. If national noise requirements use different limits (more or less stringent), this should be clearly marked, and in order to avoid confusion the ICAO limits should also be quoted.

2.2.4 *Language*

States issuing their noise certification documentation in a language other than English should provide an English translation in accordance with Part 6.

2.2.5 *References to national requirements*

Reference to national requirements can be combined with Item 18 or can be added as a separate item.

2.2.6 *Other aircraft modifications*

Other modifications from the basic aircraft model as specified under Item 5 and Items 7 through 10 to aid further identification of the noise configuration can be provided at the discretion of the State of Registry. Note that any modifications required to meet the Standards to which any document is issued should be reported under Item 12.

2.2.7 *Date of expiry*

If the State of Registry limits the validity of the noise certification documentation, it should include the date of expiry.

2.3 **Formats for noise certification documentation**

2.3.1 In view of the wide variety of administrative needs for systems for noise certification documentation, three alternative standardized options are provided:

- 1) A stand-alone noise certificate in which the mandatory information requirements of Part 16, Volume I, are contained in a single document.

- 2) Two complementary documents of which one may be the aeroplane flight manual (AFM) or the aircraft operating manual (AOM).
- 3) Three complementary documents.

2.3.2 *Option 1. One document*

The first option is an administrative system in which the document attesting noise certification takes the form of a separate noise certificate that contains all the items identified in Part II, Chapter 1, 1.5. A standard format is provided in Figure G-1. States using this format may deviate from this where needed to meet their national requirements and/or to include any additional items. It should however be generally similar to Figure G-1. Note that not all items will be mentioned on every noise certificate. For instance, not all Items 13 through 17 will be mentioned on one noise certificate since they are not all applicable to every chapter. Normally, only one certificate per aircraft serial number should be issued and be valid at the same time. If a noise certificate has lost its validity, it should be suspended or revoked to avoid the situation that more than one noise certificate is current for an aircraft. If multiple documents for this option have been issued, it should be easy to determine which document is applicable at any given time.

2.3.3 *Option 2. Two complementary documents*

2.3.3.1 The second option is an administrative system consisting of two documents in which the first official document attests noise certification, but is limited to identification of the aircraft, and the statement of compliance, containing only Items 1 through 6 and Items 18 through 20 of 2.1. This can be either in the form of a (limited) noise certificate or in the form of a certificate of airworthiness for those States that include noise requirements in their airworthiness requirements. In the latter case, there is no need for Item 18 (statement of compliance with reference to Part 16) since compliance is implicit. The numbering of the items in the certificate of airworthiness will be according to the convention in Part 8. In these cases the remaining items of 2.1 should be transferred to a complementary standardized noise certification document, normally as a page of the AFM or AOM certified by the State of Registry, the format of which can be very similar to that of the noise certificate described under 2.3.2. Therefore the format given in Figure G-1 can equally serve as a standard format for the complementary document, although some items may not be needed.

2.3.3.2 Normally only one set of the two documents should be issued for each aircraft. If a noise certification document has lost its validity, it should be suspended or revoked. If multiple documents have been issued under this option, it should be obvious from the

documentation which document is applicable at any given time.

2.3.4 Option 3. Three complementary documents

2.3.4.1 The third option is an administrative system consisting of three documents in which the first official document is identical to the first document of Option 2, 2.3.3.1. It attests noise certification and is therefore also limited to identification of the aircraft, and the statement of compliance, containing only Items 1 through 6 and Items 18 through 20 of 2.1. This can be either in the form of a noise certificate or in the form of a certificate of airworthiness for those States that include noise requirements in their airworthiness requirements (with the same observation as in the second option). The remaining items of 2.1 should be transferred to the second and third complementary noise certification documents.

2.3.4.2 The second document, normally presented as a page (or set of following pages) in the AFM or AOM, certified by the State of Registry, list(s) all the configurations operated or forecast to be operated by the aircraft fleet from the date of issuance of the page(s). The fleet is composed of all aircraft that are operated with the same flight manual. The format of the information can be very similar to that of the noise certificate described under 2.3.2, all information corresponding to a given configuration comprising Item 5 and Items 7 through 17. Each list of parameters corresponding to a given configuration is identified by a “configuration number”, for example “x”. Therefore the format given in Figure G-1 can equally serve for the items concerned, with the addition of the configuration number.


For use by State of Registry	1. <State of Registry>	3. Document number:
	2. NOISE CERTIFICATE	
4. Nationality and registration marks:	5. Manufacturer and manufacturer’s designation of aircraft:	6. Aircraft serial number:
7. Engine:	8. Propeller:*	
9. Maximum take-off mass: kg	10. Maximum landing mass:* kg	11. Noise certification Standard:

12.	Additional modifications incorporated for the purpose of compliance with the applicable noise certification Standards:				
13.	Lateral/full-power noise level:*	14. Approach noise level:*	15. Flyover noise level:*	16. Overflight noise level:*	17. Take-off noise level:*
Remarks:					
18.	This noise certificate is issued pursuant to Volume I of Part 16 to the Convention on International Civil Aviation, in respect of the above-mentioned aircraft, which is considered to comply with the indicated noise Standard when maintained and operated in accordance with the relevant requirements and operating limitations.				
19.	Date of issue		20. Signature ...		

* These boxes may be omitted depending on the noise certification Standard.

Figure G-1. Noise certificate

2.3.4.3 The third document under this option is issued according to a national regulatory process. It states that an aircraft with a given serial number has operated in the configuration number “x” since the date of issuance of this third document. If multiple documents for this option have been issued, it should be obvious from the documentation which document is applicable at any given time.

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ATTACHMENT H. GUIDELINES FOR OBTAINING HELICOPTER NOISE DATA FOR LAND-USE PLANNING PURPOSES

1. INTRODUCTION

The following guidance material has been prepared for the use of States wishing to utilize noise certification data, or optional supplementary test data, for land-use planning purposes. The purpose of this guidance material is to assist in the provision of data suitable for the prediction of helicopter noise exposure contours and to support the development of heliport noise abatement operational procedures.

2. DATA COLLECTION PROCEDURES

2.1 Data suitable for land-use planning purposes may be derived directly from Chapter 8 noise certification data. Chapter 8 applicants may optionally elect to acquire data suitable for land-use planning purposes via alternative take-off, approach and/or flyover procedures defined by the applicant and approved by the certifying authority. Alternative flyover procedures should be performed overhead the flight path reference point at a height of 150 m. In addition, an applicant may optionally elect to provide data at additional microphone locations.

2.2 Chapter 11 noise certification data may be provided for land-use planning purposes. Chapter 11 applicants may optionally elect to provide data acquired via alternative flyover procedures at 150 m above ground level. In acquiring data for land-use planning purposes, Chapter 11 applicants should give consideration to acquiring data from two additional microphones symmetrically disposed at 150 m on each side of the flight path and/or additional take-off and approach procedures defined by the applicant and approved by the certifying authority. In addition, an applicant may optionally elect to provide data at additional microphone locations.

2.3 All data provided for land-use planning purposes should be corrected to the appropriate reference conditions via the approved procedures of Chapter 8 and Chapter 11 or, for alternative flight procedures, by appropriate correction procedures approved by the certifying authority.

3. REPORTING OF DATA

3.1 All data provided for land-use planning purposes should be submitted to the certifying authority for approval. The approved data and the corresponding flight procedures should be presented as supplementary information in the helicopter flight manual.

3.2 It is recommended that all data provided for land-use planning purposes be presented in terms of average sound exposure level (L_{AE}), as defined in Appendix 4 of this volume,

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for left sideline, center line and right sideline measurement points defined relative to the direction of flight for each test pass. Additional data in other noise metrics may also be provided and should be derived in a manner that is consistent with the prescribed noise certification analysis procedure.

4. GUIDELINES FOR ACQUIRING HELICOPTER HOVER NOISE DATA 4.1

4.1 The primary objective for these guidelines on acquiring helicopter hover noise data is to achieve sufficient commonality in measurement conditions and locations, including hover heights, radial measurement distance, azimuthal directions and microphone configuration, to permit direct comparability between different hover noise datasets. These guidelines are therefore not intended to be comprehensive procedures for hover noise testing, but rather recommendations for the measurements to be included in hover noise test programs to achieve this objective. Furthermore, these guidelines do not supersede requirements for safe flight of the aircraft and use of the guidelines should be subject to compliance with airworthiness limitations for hover operations of the helicopter. The guidelines are presented below.

4.2 Aircraft hover height: Elevated noise levels are typically generated by helicopters due to high power requirements needed to maintain hover position. The power required to maintain hover position is reduced when operating “in ground effect” (IGE), a condition of improved performance encountered when operating near (within 1/2 rotor diameter) the ground. Near-maximum power is required when operating “out of ground effect” (OGE). Hover heights for helicopter hover noise testing are recommended as follows: a) IGE Hover: 1.5 m (5 ft) wheel or skid clearance is recommended; and b) OGE Hover: The recommended hover height for OGE hover noise measurements is 30 m (100 ft) or the minimum airworthiness-approved height to hover, whichever is greater. A minimum airworthiness-approved height to hover greater than 30 m (100 ft) is more common for single-engine helicopters. Acquiring OGE hover noise data at a height of 60 m (200 ft) and/or 90 m (300 ft) is also recommended when possible. If the airworthiness-approved minimum height for OGE hover is greater than 30 m (100 ft) but less than 60 m (200 ft) or 90 m (300 ft), increasing the OGE hover test height from the minimum airworthiness-approved height to 60 m (200 ft) and/or 90 m (300 ft) is recommended. At a minimum, it is recommended that OGE hover noise data are acquired for at least one of these recommended heights. The OGE hover height(s) should be reported with the noise data.

- a) IGE Hover: 1.5 m (5 ft) wheel or skid clearance is recommended; and
- b) OGE Hover: The recommended hover height for OGE hover noise measurements is 30 m (100 ft) or the minimum airworthiness-approved

height to hover, whichever is greater. A minimum airworthiness-approved height to hover greater than 30 m (100 ft) is more common for single-engine helicopters. Acquiring OGE hover noise data at a height of 60 m (200 ft) and/or 90 m (300 ft) is also recommended when possible. If the airworthiness-approved minimum height for OGE hover is greater than 30 m (100 ft) but less than 60 m (200 ft) or 90 m (300 ft), increasing the OGE hover test height from the minimum airworthiness-approved height to 60 m (200 ft) and/or 90 m (300 ft) is recommended. At a minimum, it is recommended that OGE hover noise data are acquired for at least one of these recommended heights. The OGE hover height(s) should be reported with the noise data.

4.3 Aircraft position: For each hover noise measurement, it is recommended that the aircraft be maintained on condition for a minimum of 30 seconds with aircraft longitudinal and lateral position maintained within +/- 7.6 m (25 ft) referenced to the target main rotor hub position. It is recommended for aircraft vertical position to be maintained within +/- 1.5 m (5 ft) for IGE conditions and +/- 3 m (10 ft) for OGE conditions.

Note. Aircraft position is a second order effect as it relates to hover noise data quality. Data obtained outside of these aircraft position guidelines may be usable if first order guideline parameters are achieved. Note that an approximate adjustment to the measured noise data of 20 log (average test distance/reference distance) can be applied if +/- 7.6 m (25 ft) is exceeded.

4.4 Aircraft gross mass and rotor speed: It is recommended to maintain gross mass within -10 per cent of maximum certificated take-off mass and rotor speed within +/- 1 per cent of maximum normal operating speed.

4.5 Meteorological conditions: Helicopter hover noise can be highly variable and most sensitive to variation in wind speed or direction. This is true even for helicopters equipped with advanced flight control systems that make automatic control inputs enabling the helicopter to maintain position during gusty conditions. Meteorological conditions for conducting helicopter hover noise tests are recommended as follows:

- a) Wind speed is a first order effect as it relates to hover noise and should be considered a key metric for data quality assessment. Hover noise data should be obtained with 30-second average wind speed measured at 10 m of < 2.6 m/s (5 kt), however, < 1.5 m/s (3 kt) is strongly preferred to reduce variability;
- b) Recommended limits for temperature and relative humidity at 10 m (33 ft) are -10 to 35o C (14 to 95o F) and 20 to 95 per cent, respectively. Any adjustments to the measured data for temperature and relative humidity should be based on a reference temperature of 25o C (77o F) and a reference relative humidity of 70 per cent; and

c) Temperature, humidity and atmospheric absorption are generally second order effects as they relate to hover noise data quality, but temperature inversions can significantly impact hover noise levels. Early morning testing is often most practical for obtaining low wind hover noise data, but low altitude temperature inversions can also be encountered during early morning hours. The primary recommendation is to conduct atmospheric measurements to ensure that temperature inversions that could significantly impact hover noise measurements are not present. Otherwise, test teams may encounter a delicate balance between testing as early as possible to take advantage of stable, low wind conditions and delaying early morning testing until temperature inversions become unlikely.

4.6 Ground surface: The recommended ground surface near each microphone is mowed grass as described in the Environmental Technical Manual (Doc 9501).

4.7 Non-acoustic data: It is recommended to acquire data for the following non-acoustic parameters, as provided in Table H-1. These parameters are ranked by priority 1 or 2 and should be reported with hover noise measurements. For wind speed and direction, temperature and relative humidity, it is recommended that a 30-second average concurrent with the acoustic measurement be reported if available.

Table H-1. Non-Acoustic Data Parameters

Priority 1	Priority 2
Wind speed and temperature at 10 m (33 ft)	Relative humidity at 10 m (33 ft)
Wind direction at 10 m (33 ft)	Aircraft rotor speed (instantaneous RPM)
Aircraft position (Lat / Long / Vertical)	Aircraft gross mass (instantaneous)
Aircraft temperature (OAT)	Aircraft power (Torque or horsepower)
Aircraft rotor speed (nominal RPM)	Aircraft heading (instantaneous)
Aircraft gross mass (nominal)	-
Aircraft heading (nominal)	-

4.8 Data analysis: Noise level data should be measured and averaged for a minimum of 30 seconds for each hover noise measurement. The average A-weighted value based on slow time averaging is recommended for reporting purposes. Additional metrics (linear, C-weighted, etc.) may be assessed and reported.

4.9 Microphone configuration: Microphones should be mounted on a 1.2 m (4 ft) microphone stand with grazing incidence. Research is ongoing regarding the use of ground plane microphones and are not recommended as a sole microphone configuration for hover noise measurements at this time. However, concurrent ground plane measurements are recommended for potential future use. The microphone configuration used for hover noise measurements should be reported. A windscreen is normally not needed for windspeeds below 3 m/s (6 kt) but is recommended for acquisition of helicopter hover noise data.

4.10 Radial distance(s) of measurement locations: A radial distance of 150 m (492 ft) or 500 ft is recommended for hover noise measurements, as this distance has been commonly used by manufacturers. Radial distances of 150 m (492 ft) and 500 ft are sufficiently close to be considered equivalent for hover noise measurement purposes.

4.11 Azimuthal measurement locations: Helicopter hover noise has been shown to be highly directional with maximum amplitudes directed toward the aft quadrant of the aircraft. It is important to measure hover noise data at azimuthal positions fully encompassing the aircraft and with the best azimuthal resolution as is reasonable. The recommended azimuthal measurements at 150 m (500 ft) from the helicopter are summarized in Table H-2. Primary recommendations encompass measurements at 30o resolution for a full circle around the aircraft plus four additional measurements at 45o, 135o, 225o and 315o. The secondary measurements are not specifically sought by these guidelines but can be acquired in the process of getting the primary recommended measurements.

Table H-2. Recommended Azimuthal Measurements with Initial Measurement Defined as 0/360°

Recommended Measurement Locations	
Primary	Secondary
0/360°	-
-	15°
30°	-
45°	-
60°	-
-	75°
90°	-

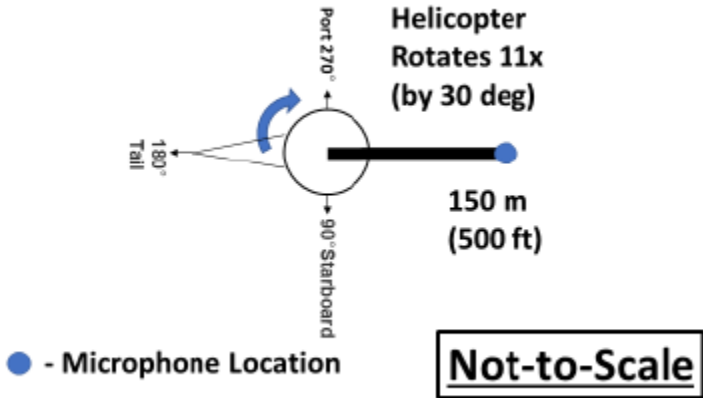
-	105°
120°	-
135°	-
150°	-
-	165°
180°	-
-	195°
210°	-
225°	-
240°	-
-	255°
270°	-
-	285°
300°	-
315°	-
330°	-
-	345°

4.12 Microphone array: Multiple microphone array configurations ranging from a single microphone to 24 microphones can be used to obtain the azimuthal measurements defined in Table H-2. The choice of microphone array will inherently incur a trade-off between ease of deployment/test setup (number of microphones/data channels) and total test time (number of aircraft rotations needed to get the recommended azimuthal measurements). It is also recognized that, often, test site constraints and/or equipment availability will determine the microphone array that can be deployed for a hover noise test. As the low wind conditions conducive to quality hover noise measurements can be transitory, higher number microphone array configurations with fewer rotations, and

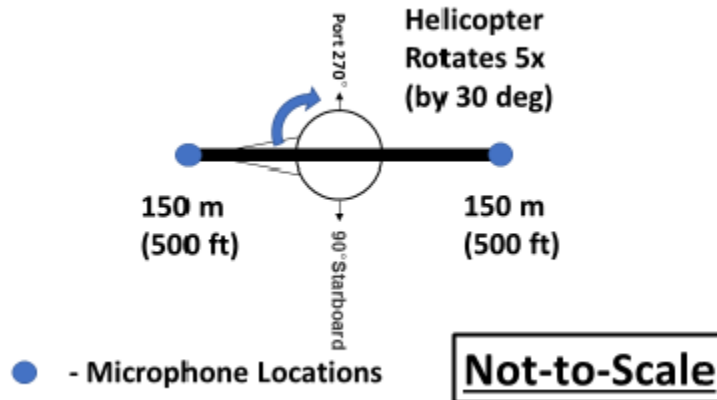
thereby less total test time, can be beneficial to the acquisition of a comprehensive and high-quality hover noise data set as well as providing greater opportunity for repeat azimuthal measurements. All of these trade-offs should be considered when planning a helicopter hover noise measurement programme.

4.13 Example microphone arrays: The potential combinations of microphone arrays and aircraft rotation sequences that can provide the azimuthal measurements in Table H-2 are too numerous to describe here. Some of the various microphone arrays that have been used are described below.

- a) Linear microphone arrays: When constrained by the available number of microphones and/or data acquisition channels, a one-side (single microphone) or two-sided (two microphones) linear array as depicted in Figure H-1 (a) or (b) has been utilized. When not so constrained, additional microphone locations have been added to these linear arrays at, for example, 50 m or 75 m (250 ft) intervals. Note that the microphone array depicted in Figure H-1 (b) is deployed for noise certification testing, presenting an opportunity to acquire hover noise data concurrent with a noise certification test programme. Aircraft position should be maintained on condition in accordance with section 4.3, above, while hover noise data are acquired at the initial azimuthal position. The aircraft then rotates by 30o increments and data are acquired on condition as shown in Figures H-1 (a) and (b) until the full azimuthal range is obtained with 30-degree resolution. Additional rotations are needed to get data at 45o, 135o, 225o and 315o or obtained during 15-degree rotations which are an option for increased azimuthal resolution. At least one aircraft azimuthal position should be repeated to assess hover noise variability;



(a) Single-sided (single microphone) linear array



(b) Two-sided (two microphones) linear array

- b) Full-circle microphone array: Microphones can be deployed in a full circle around the hover point at 90o, 45o, 30o or 15o resolution (and at 45o, 135o, 225o and 315o if needed) to get the recommended azimuthal positions in Table H-2, potentially in a single noise measurement. An eight-microphone, full-circle array with 45o resolution is shown in Figure H-2 which has been used for hover noise measurements. With two aircraft rotations of 30o each, all of the primary azimuthal measurements in Table H-2 can be acquired with this array;

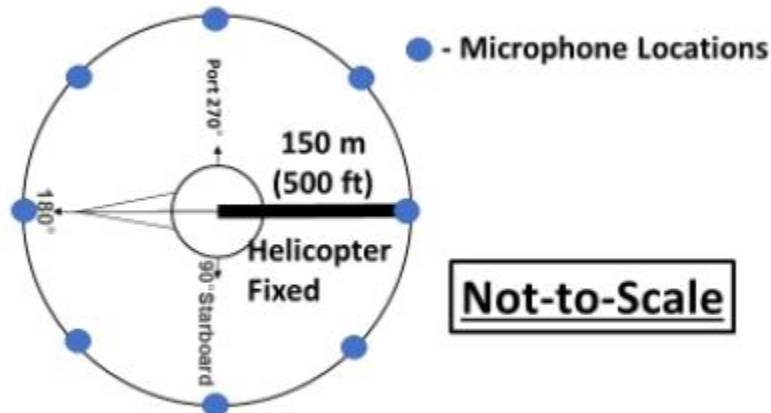


Figure H-2. Circular Microphone Array

- c) Half-circle microphone array: A half-circle array has been utilized to acquire the recommended measurements in Table H-2 with repeated measurements



obtained for a single full rotation of the aircraft. This array, with 30° spacing between microphones, can be optionally extended with additional radial distance measurements as shown in Figure H-3. For this example half-circle array, all of the primary recommended azimuths in Table H-2 can be acquired with a 45° – 45° – 90° – 45° – 45° rotation sequence, but if a full set of seven 45° rotations is performed, all of the primary and secondary recommended measurements in Table H-2 are acquired with two or three measurements at each azimuth. The full data set using 45° rotations is described in Table H-3 with the initial aircraft azimuth (0/360°) aligning with measurement location D in Figure H-3.

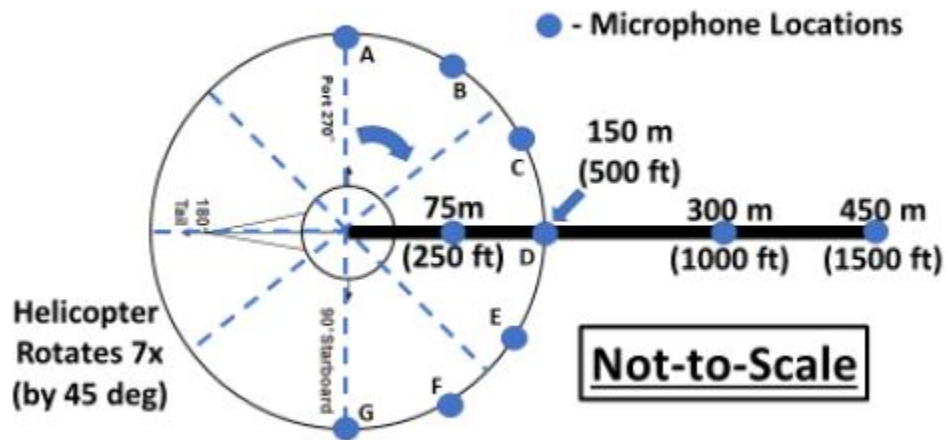


Figure H-3. Hybrid Linear and Half-Circle Array: Seven 45° Rotations



**Table H-3. Azimuthal Measurements Acquired with the Half-circle Test Setup
in Figure H-3**

Azimuthal Measurement	Rotation from Starting Position							No. of Repeats	
	0	45	90	135	180	225	270		315
0/360	D		G				A		3
15		F						C	2
30	E						B		2
45		G				A		D	3
60	F						C		2
75						B		E	2
90	G				A		D		3
105						C		F	2
120					B		E		2
135				A		D		G	3
150					C		F		2
165				B		E			2
180			A		D		G		3
195				C		F			2
210			B		E				2
225		A		D		G			3
240			C		F				2
255		B		E					2
270	A		D		G				3
285		C		F					2
300	B		E						2
315		D		G				A	3
330	C		F						2
345		E						B	2

- d) Examples of other part-circle arrays are not presented here, but there are additional options including one-third, one-quarter or smaller arrays that could be used to meet test site and/or equipment constraints.

END