Aircraft Airworthiness Certification Department
of Civil Aviation Administration of China
(CAAC-AAD)

Advisory Circular

No. : AC-36-AA-2008-04
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NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION

1. PURPOSE.

a. Contents: This advisory circular (AC) contains information concerning the aircraft noise certification requirements of part 36 of the Chinese Civil Aviation Regulations (CCAR-36). The document includes general information, references and definitions related to part 36, followed by regulatory language of all sections of part 36 Subparts and Technical Appendices. Explanations of regulatory language, CAAC policies for implementation of the regulatory language and other guidance information are provided for each section, as appropriate. Four appendices are also attached and referenced within the body of the AC. These include the ICAO Environmental Technical Manual as identified below, a description of CAAC procedures for auditing an applicant's data adjustment and analysis methods, a methodology for adjusting data for the effects of ambient noise, and information on equivalent procedures and demonstrating "no acoustical change" for propeller-driven small airplanes and commuter category airplanes.

b. Scope: This AC provides information for interested parties (such as regulatory authorities, aircraft manufacturers, acoustic consultants, airline and airport operators and others) on compliance with the part 36 noise certification regulations, including CAAC policies and interpretations of regulatory language and other technical guidance applicable to noise certification processes for airplane and rotorcraft classes of aircraft. It is applicable for noise certification of normal, utility, acrobatic, commuter and transport category airplanes and normal and transport category rotorcraft as defined in part 21.

This AC does not change regulatory requirements and does not authorize changes in, or deviations from, regulatory requirements. This document contains some mandatory language, where it is appropriate, as well as language that is permissive and advisory in nature. Mandatory language (e.g. the term "must") is used in the AC for "Explanations of regulatory language". Mandatory language is also used for certain "Supplementary Information" and "Procedures" to reflect CAAC policies regarding compliance with the intent of regulatory language. Permissive language (e.g. the term "should") is used in this AC, to identify conditions and/or methods and procedures that may be acceptable to the CAAC for purposes of aircraft noise certification based upon experience to date, but where an applicant is not constrained from considering or validating and proposing alternatives for compliance with part 36.

Many equivalent procedures are referred to in this document since they have become acceptable practices for aircraft noise certification applications. Appendix 1 of this document is Steering Group Approved Revision 7 (SGAR7) of the "Environmental Technical Manual on the Use of Procedures in the Noise Certification of Aircraft" developed by the ICAO Committee on Aviation Environmental Protection (CAEP). This AC references specific Technical Manual equivalent procedures that may be considered acceptable by CAAC for aircraft noise certification applications. The acceptability of an equivalent procedure for an aircraft noise certification application is subject to CAAC review and approval.

c. Document Format: This AC contains a section-by-section review of part 36 as shown in Figure 1:

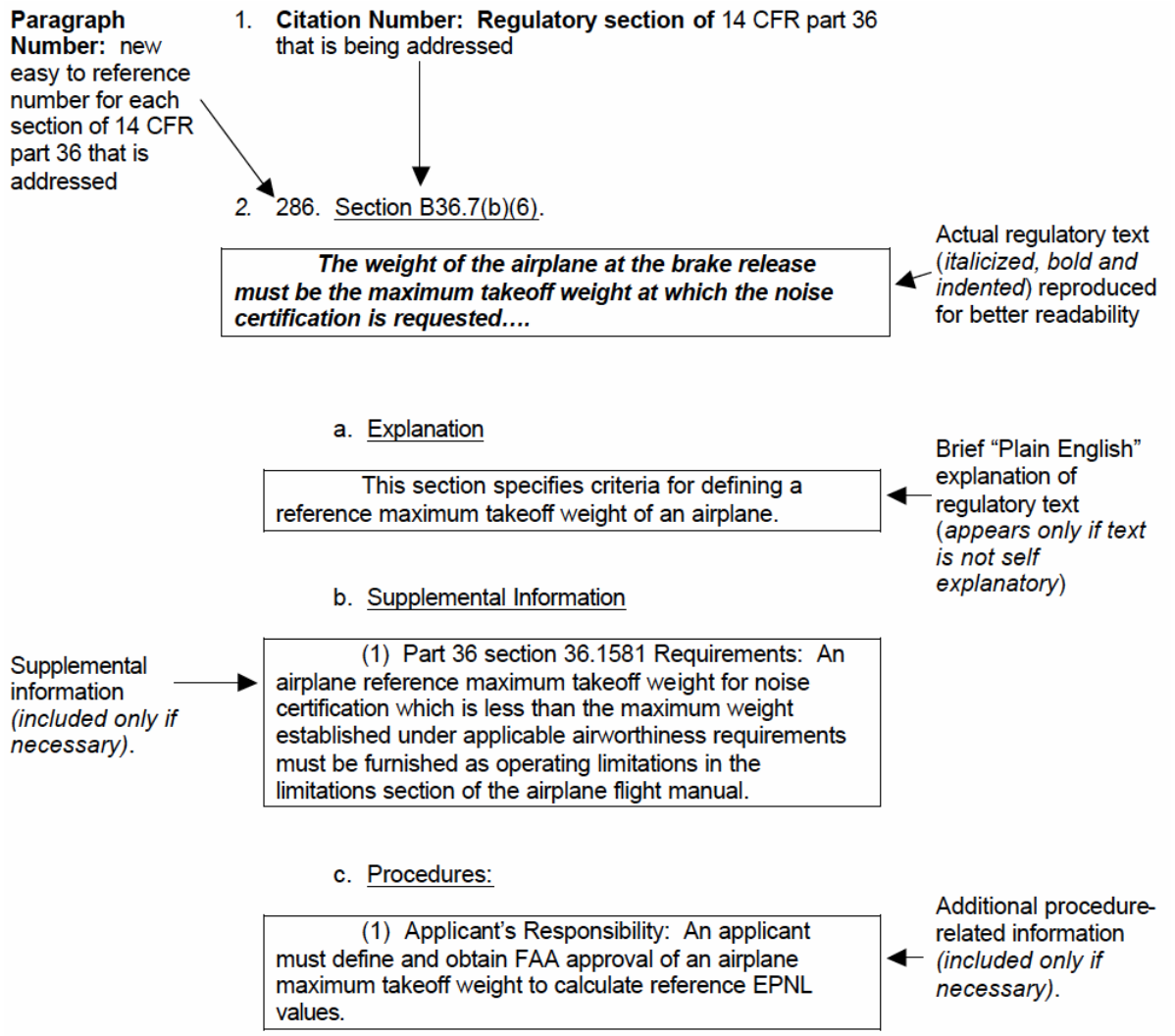


FIGURE 1: Document Format

d. Exclusions: The following topics are not addressed in this AC:

(1) This document does not review the noise certification requirements for supersonic transport category airplanes.

(2) This document does not review part 36 Appendix F, “Flyover Noise Requirements for Propeller-Driven Small Airplane and Propeller-Driven, Commuter Category Airplane Certification Tests Prior to November 17, 1988.” Appendix F has been superseded by Appendix G.

(3) This document does not review the aircraft operational limitations that may be imposed on certificated civil aircraft operating within the People’s Republic of China.

2. [RESERVED]

3. REFERENCES.

(1) FAA Order 1050.1D, Policies and Procedures For Considering Environmental Impacts, (Change 4, June 14, 1999), or current version

(2) Public Law 103-272, Codification of Certain U.S. Transportation Laws as Title 49, United States Code, Section 44715, July 5, 1994

(3) Part 36, Appendix G Handbook, FAA Report FAA-AEE-95, dated June 20, 1995

(4) Requirements for DGPS-Based TSPI Systems Used in Aircraft Noise Certification Tests, DTS-75-FA753-LR3, Letter Report, April 14, 1997

(5) Joint Aviation Requirements, JAR 36, Aircraft Noise, May 1997

(6) Advisory Circular (AC) 25-7A, Flight Test Guide, March 31, 1998, or current version

(7) FAA Order 8110.4B, Type Certification Process, April 24, 2000, or current version

(8) ICAO Committee on Aviation Environmental Protection (CAEP), Environmental Technical Manual on theUse of Procedures in the Noise Certification of Aircraft, Steering Group Approved Revision (SGAR) 7, September 2000 (included as Appendix 1 to this AC)

(9) FAA Order 8100.8A, Designee Management Handbook, January 30, 2001, or current version

(10) FAA Order 8110.37C, September 30, 1998. Designated Engineering

Representatives (DER) Guidance Handbook, or current version

(11) International Civil Aviation Organization (ICAO), Environmental Protection, Annex 16, Volume 1, Aircraft Noise, Third Edition - 1993. (Amendment 7, Applicable March 21, 2002)

4. DEFINITIONS.

This section contains two categories of Definitions that are used within the regulatory language, policies or other guidance information of this Advisory Circular. The first category defines general terms in the part 36 noise certification process. The second category defines specific aircraft types that must comply with part 36 regulations and other items related to those aircraft.

a. General Definitions:

(1) Administrator: means the General Administration of Civil Aviation of China (hereafter referred to as CAAC), the CAAC regional administrations and any organization operating under the authorization of the CAAC.

(2) [RESERVED]

(3) Applicant: CCAR 21.13, states: “Any person capable of civil aviation products design may apply for a type certificate and/or type design approval to CAAC”. The person that applies to the CAAC for an aircraft type certificate, whether a new (original), supplemental type certificate, is identified as the “applicant” and is the entity that must comply with the relevant requirements of CCAR-21.

(4) [RESERVED]

(5) [RESERVED]

(6) Type Inspection Authorization (TIA): The TIA is the official CAAC document that provides direction and communication between the local certification organization engineering group and the CAAC flight test crew. The TIA usually mandates the provisions of an applicant’s approved demonstration compliance plan and any additional restrictions, inspections, tests, limitations, procedures, etc., that are required by the Administrator to be observed during the conduct of the flight or ground testing.

b. Definitions Related to Aircraft

(1) Aircraft: A device that is used or intended to be used for flight in the

air.

(2) Large Aircraft: Large aircraft means aircraft of more than 5,700 kg (12,500 pounds), maximum certificated takeoff weight.

(3) Small Aircraft: Small aircraft means aircraft of 5,700 kg (12,500 pounds) or less, maximum certificated take-off weight.

(4) Civil Aircraft: Aircraft other than the aircraft which used only in the service of military, customs or police.

(5) Airplane: An engine-driven fixed-wing aircraft heavier than air that is supported in flight by the dynamic reaction of the air against its wings.

(6) Acrobatic Category Airplane: The acrobatic category is limited to airplanes that have a seating configuration, excluding pilot seats, of nine or less, a maximum certificated take-off weight of 5,700 kg (12,500 pounds) or less, and intended for use without restrictions, other than those shown to be necessary as a result of required flight tests. Acrobatic category airplanes are required to show compliance with CCAR-23.

(7) Commuter Category Airplanes: The commuter category is limited to propeller-driven, multiengine airplanes that have a seating configuration, excluding pilot seats, of 19 or less, and a maximum certificated takeoff weight of 8,618 kg (19,000 pounds) pounds or less, intended for non-acrobatic operations. Commuter category airplanes are required to show compliance with CCAR-23.

(8) Normal Category Airplane: The normal category is limited to airplanes that have a seating configuration, excluding pilot seats, of nine or less, a maximum certificated take-off weight of 5,700 kg (12,500 pounds) or less, and intended for nonacrobatic operation. Normal category airplanes are required to show compliance with CCAR-23.

(9) Primary Category Aircraft: A primary category aircraft is an aircraft that

(i) is unpowered, or is an airplane powered by a single, naturally aspirated engine with a 113-km per hour (61-knot) or less stall speed, or is a rotorcraft with a 29.3-kg per square metres (6-pound per square foot) main rotor disc loading limitations, and

(ii) weighs not more than 1,225 kg (2,700 pounds), and

(iii) has a maximum seating capacity of not more than four persons,

including the pilot, and

(iv) has an unpressurized cabin.

A primary category aircraft is required to meet the regulatory requirements of CCAR-21, section 21.24.

(10) Restricted Aircraft: Used for special purpose operations as defined in CCAR-21, section 21.25

(11) Transport Category Aircraft: Those aircraft (large or small) that are demonstrated to meet and are certificated to the regulatory requirements of CCAR-25 for transport category airplanes or CCAR-29 for transport category rotorcraft.

(12) Utility Category Airplane: The utility category is limited to airplanes that have a seating configuration, excluding pilot seats, of nine or less, a maximum certificated take-off weight of 5,700 kg (12,500 pounds) or less, and intended for limited acrobatic operation. Utility category airplanes are required to show compliance with CCAR-23.

(13) Helicopter: A rotorcraft that, for its horizontal motion, depends principally on its engine-driven rotors.

(14) Rotorcraft: A heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors.

(15) Normal Category Rotorcraft: A normal category rotorcraft is a rotorcraft with a maximum weight of 3,180 kg (7,000 pounds) or less and that meets the regulatory requirements of CCAR-27.

(16) Jet Airplane: Any fixed wing airplane that is powered by a turbojet or turbofan engine regardless of whether it is an airplane certificated to CCAR-23 (small or commuter aircraft) or CCAR-25 (transport category aircraft).

(17) Turbo-propeller Airplane: An airplane whose primary source of thrust is from a propeller driven by a gas turbine engine.

(18) Subsonic airplane: A subsonic airplane means an airplane for which the maximum operating limit speed, M_{MO}, does not exceed a Mach number of 1.

(19) Supersonic airplane: A supersonic airplane means an airplane for which the maximum operating limit speed, M_{MO}, exceeds a Mach number of 1.

(20) Aircraft Engine: An engine that is used, or intended to be used, for

propelling aircraft. It includes turbosuperchargers, appurtenances, and accessories necessary for its functioning, but does not include propellers.

(21) Propeller: A device for propelling an aircraft that has blades on an engine-driven shaft and that, when rotated, produces by its action on the air, a thrust approximately perpendicular to its plane of rotation. It includes control components normally supplied by its manufacturer, but does not include main and auxiliary rotors or rotating airfoils of engines.

(22) Airport: An area of land or water that is used or intended to be used for the landing and take-off of aircraft, and includes its buildings and facilities, if any.

(23) [RESERVED]

5. ABBREVIATION AND ACRONYMS.

Note: In addition to the abbreviations and acronyms contained in this paragraph, section A36.6 of this AC contains symbols and units associated with the noise certification standards for subsonic transport category large airplanes and jet airplanes.

AC	Advisory Circular
A/C	Air-conditioning (Environmental Control System)
AFM	Airplane Flight Manual
APU	Auxiliary Power Unit
ARP	Aerospace Recommended Practice
CAAC	Civil Aviation Administration of China
CCAR	Chinese Civil Aviation Regulation
CDI	Course Deviation Indicator
CG	Center of Gravity
dB	decibels

DER	Designated Engineering Representative
DGPS	Differential Global Positioning System
DMU	Distance Measuring Unit
EPR	Engine Pressure Ratio (Power Setting Parameter)
FAA	Federal Aviation Administration
GDI	Glide-slope Deviation Indicator
GPS	Global Positioning System
Hz	oscillatory frequency, cycles per second
INS	Inertial Navigation System
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
ISA	International Standard Atmosphere
JAR	Joint Aviation Requirements (of Europe)
Log	logarithmic value to base 10
m	meter
MLW	Maximum Landing Weight
MSL	Mean Sea Level altitude
MTOGW	Maximum Take-off Gross Weight
N_1	Low Pressure Rotor Speed (Power Setting Parameter), rpm or %
NAC	No Acoustical Change
NCS	Noise Certification Specialist

NIST	National Institute of Standards and Technology
NPD	Noise-Power-Distance
RFM	Rotorcraft Flight Manual
RH	Relative Humidity, %
rms	root-mean-square
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SBV	Surge Bleed Valve (engine internal operating valves)
STC	Supplemental Type Certificate
TIA	Type Inspection Authorization
TC	Type Certificate
TM	Technical Manual ("ICAO Environmental Technical Manual on the use of Procedures in the Noise Certification of Aircraft")
TSPI	Time Space Positional Information
V_{REF}	Reference Landing Speed

6. - 7. RESERVED.

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I. CERTIFICATION PROCEDURES FOR PRODUCT AND PARTS CCAR-21

8. PART 21 – GENERAL

As part of the overall aircraft certification requirements identified in CCAR-21, applicants must comply with the noise certification requirements of CCAR-36. An applicant for a type certificate must show that the aircraft meets the applicable requirements of CCAR-36 (CCAR-21, section 21.17). In addition, an applicant is entitled to a type certificate for an aircraft if the applicant submits the type design, test reports, and computations necessary to show that the product to be certificated meets the applicable airworthiness and aircraft noise requirements (CCAR-21, sections 21.21 & 21.25). Similar requirements are imposed for aircraft manufactured in a foreign country for import into China (CCAR-21, section 21.29). Refer to the CCAR-21 regulations for specific regulatory language.

a. Explanation

None

b. Supplemental Information

(1) Airworthiness Certification: All aircraft requiring noise certification by the CAAC are required to meet the applicable airworthiness requirements of CCAR-21, which identifies the specific airworthiness standards for each aircraft type and product, such as:

(i) CCAR-23 for normal, utility, acrobatic, and commuter category airplanes,

(ii) CCAR-25 for transport category airplanes,

(iii) CCAR-27 for normal category rotorcraft,

(iv) CCAR-29 for transport category rotorcraft,

(v) CCAR-33 for aircraft engines,

(vi) CCAR-35 for propellers,

(vii) Primary category aircraft.

(2) Changes in Type Design. CCAR-21 section 21.93(b) requires compliance with the appropriate part 36 “acoustical change” requirements for a

voluntary type design change of an aircraft that may increase the noise levels of that aircraft, regardless of whether the change in type design is classified as a minor or major change in CCAR-21, section 21.93(a). See paragraph 16 of this AC for further discussion of acoustical change.

c. Procedures

None

9.-11. [RESERVED]

II. CCAR-36: NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION

12. SUBPART A GENERAL

a. Explanation

This Subpart specifies the Applicability of CCAR-36, Definitions of Terms Unique to CCAR-36, CCAR-36 Requirements as of the Date of Type Certificate Application, Airworthiness Compatibility requirements, Limitations, Information on References, and Acoustical Change Requirements.

b. Supplemental Information

None

c. Procedures

None

13. Section 36.1 Applicability and definitions

14. Section 36.1(a)

(a) This part prescribes noise standards for the issue of the following certificates，and changes to those certificates:

(1) Type Certificates, Supplemental Type Certificates, Modification Design Approvals, and Standard Airworthiness Certificates, for subsonic transport category large airplanes, and for subsonic jet airplanes, except as otherwise specifically provided by CAAC. The "subsonic transport category large airplanes and subsonic jet airplanes" in this part means propeller-driven aeroplanes over 8618 kg (19000 lb) maximum takeoff weight and subsonic jet aeroplanes regardless of category, other than jet aeroplanes which require a runway length of 610 m of less at maximum takeoff weight.

(2) Type Certificates, Supplemental Type Certificates, Type Design Approvals, Modification Design Approvals, and Standard Airworthiness Certificates, Restricted Category Special Airworthiness Certificates, for propeller-driven small airplanes, and for propeller-driven commuter category airplanes, except those airplanes that are specified under §36.1583 of this part or otherwise provided by CAAC. The "propeller-driven small airplanes and propeller-driven commuter category airplanes" means propeller-driven

aeroplanes not exceeding 8618 kg (19000 lb) maximum takeoff weight.

(3) [Reserved]

(4) Type Certificates, Supplemental Type Certificates, Type Design Approvals, Modification Design Approvals, and Standard Airworthiness Certificates, Restricted Category Special Airworthiness Certificates, for helicopters, except those helicopters that are designated exclusively for "agricultural aircraft operations", for dispensing fire fighting materials, or for carrying external loads, or otherwise provided by CAAC.

a. Explanation

This section specifies aircraft types and categories to which part 36 requirements are applicable as a condition for issuance of type certificates (TC), changes to type certificates, supplemental type certificates (STC), amended type certificates and airworthiness certificates.

b. Supplemental Information

(1) Applicable Requirements: Unless otherwise specified, the date to be used for determining the applicability of the appropriate part 36 standards for an aircraft type design is the date on which application for a type certificate was made. An application for type certification is effective for the time periods specified in section 21.17(c) of part 21.

(2) Noise Related Type Certification Requirements: See paragraph 6-3(h) of reference 7 of this AC.

(3) Supplemental Type Certificates: See paragraph 6-3(j) of reference 7 of this AC.

(4) Definitions of Terms: Paragraph 4 of this Advisory Circular provides definitions for the following terms related to the aircraft types and categories within Items (1) – (4) of section 36.1(a).

Aircraft

Large Aircraft

Small Aircraft

Airplane

Helicopter

Airplane Categories (See Note A)

- Acrobatic

- Commuter

- Normal

- Primary

- Restricted (See Note B)

- Transport

- Utility

Helicopter Categories

- Normal

- Transport

Propeller

Jet Airplane

Turboprop Airplane (See Note C)

Notes:

(A) Airplane Categories and Aircraft Classes: 14 CFR Part 1 recognizes a distinction between Airplane Categories (e.g., acrobatic, commuter, normal, primary, restricted, transport and utility) and Aircraft Classes (e.g., Conventional Takeoff and Landing (CTOL), Vertical Takeoff and Landing (VTOL), Short Takeoff and Landing (STOL), Reduced Takeoff and Landing (RTOL), and Supersonic Transports (SST)). The noise certification requirements contained in part 36 are specified for several Airplane and Helicopter Categories but not for STOL, RTOL, SST (except for Concorde), or VTOL Aircraft Classes.

(B) Restricted Category Propeller-Driven Large Airplanes: Propeller-driven large airplanes that have been type certificated in the restricted category (See part 21, section 21.25) are not required to demonstrate compliance with the requirements of part 36. In the absence of part 36 applicability, an Environmental Assessment is required (See FAA Order 8110.B (reference 7 of this AC) paragraph 6-3(d) for additional information).

(C) Turboprop Airplanes: Turboprop-powered airplanes are included under the part 36 requirements applicable to propeller-driven airplanes (i.e. subsonic transport category large airplanes; propellerdriven small airplanes, including

acrobatic, normal, restricted, and transport categories; or propeller-driven commuter category airplanes).

c. Procedures

None

15. Section 36.1(b)

Each person who applies for a type of airworthiness certificate specified in this part must show compliance with the applicable requirements of this part, in addition to the applicable airworthiness requirements of China Civil Aviation Regulations (CCAR).

a. Explanation

This section specifies that an applicant must comply with appropriate airworthiness requirements and part 36 requirements as a part of the total aircraft certification process.

b. Supplemental Information

(1) Aircraft Configuration for Noise Certification: An applicant's proposal for an aircraft configuration to be certified under the requirements of part 36 must include any type design changes that may be a result of airworthiness standards testing and analysis, and which would result in acoustical changes (See section 36.1(c), Supplemental Information item number (2) for criteria on when aircraft type design changes represent an acoustical change). If an applicant does not propose the appropriate aircraft configuration, additional noise certification testing and analysis may be required.

c. Procedures

None

16. Section 36.1(c).

Each person who applies for approval of an acoustical change must show that the aircraft complies with the applicable provisions of Sections 36.7, 36.9, or 36.11 of this part in addition to the applicable airworthiness requirements of CCAR.

a. Explanation:

This section specifies part 36 requirements when "voluntary" changes are

made to the type design of an aircraft under the provisions of part 21.

b. Supplemental Information:

(1) Acoustical Change: 14 CFR Part 21, section 21.93(b) defines an aircraft "acoustical change" and specific aircraft configurations excepted from part 36 requirements. The text of 14 CFR part 21, section 21.93(b) is as follows (Also see paragraph 6-3(i) of reference 7 of this AC).

(b) For the purpose of complying with part 36 of this chapter, and except as provided in paragraphs (b)(2), (b)(3), and (b)(4) of this section, any voluntary change in the type design of an aircraft that may increase the noise levels of that aircraft is an "acoustical change" (in addition to being a minor or major change as classified in paragraph in paragraph (a) of this section) for the following aircraft:

(1) Transport category large airplanes.

(2) Jet (Turbojet powered) airplanes (regardless of category). For airplanes to which this paragraph applies, "acoustical changes" do not include changes in type design that are limited to one of the following–

(i) Gear down flight with one or more retractable landing gear down during the entire flight, or

(ii) Spare engine and nacelle carriage external to the skin of the airplane (and return of the pylon or other external mount), or

(iii) Time-limited engine and/or nacelle changes, where the change in type design specifies that the airplane may not be operated for a period of more than 90 days unless compliance with the applicable acoustical change provisions of part 36 of this chapter is shown for that change in type design.

(3) Propeller driven commuter category and small airplanes in the primary, normal, utility, acrobatic, transport, and restricted categories, except for airplanes that are:

(i) Designated for "agricultural aircraft operations" (as defined in 34 137.3 of this chapter, effective January 1, 1966) to which § 36.1583 of this chapter does not apply, or

(ii) Designated for dispensing fire fighting materials to which § 36.1583 of this chapter does not apply, or

(iii) US registered, and that had flight time prior to January 1, 1955 or

(iv) Land configured aircraft reconfigured with floats or skis. This reconfiguration does not permit further exception from the requirements of this section upon any acoustical change not enumerated in § 21.93(b).

(4) Helicopters, (except for those helicopters that are designated exclusively for "agricultural aircraft operations", as defined in § 137.2 of this chapter, as effective on January 1, 1966, for dispensing fire fighting materials, or for carrying external loads, as defined in § 133.1(b) of this chapter, as effective on December 20, 1976). For helicopters to which this paragraph applies, "acoustical changes" include the following type design changes:

(i) Any changes to, or removal of, a muffler or other component designed for noise control.

(ii) Any other design or configuration change (including a change in the operating limitations of the aircraft) that, based on FAA-approved analytical or test data, the Administrator determines may result in an increase in noise level."

(2) Voluntary Changes in Type Design: A voluntary change in the configuration of an aircraft means a change in the type design of that aircraft. Examples of voluntary changes in aircraft type design that may affect part 36 certificated noise levels are as follows:

(i) Increased engine thrust (power) to improve aircraft performance;

(ii) Maximum gross weight changes;

(iii) Limitations on operational flap settings related to noise;

(iv) Hardware revisions (e.g., vortex generators, flap configuration, wing tip stabilizers, wing tip fuel tanks, etc.);

(v) Engine modifications to improve engine performance, acceleration, deceleration, or surge margin protection;

(vi) Addition of wing or body hardware to improve aerodynamics;

(vii) External nacelle changes to improve air flow patterns;

(viii) Engine inlet changes to improve ice protection;

(ix) Reduction of engine blade tip clearances to improve inlet flow characteristics, and;

(x) Modifications to engine/nacelle acoustic treatments.

(3) Acoustical Change Criteria: A voluntary change in the type design of an aircraft that may result in an increase in its certificated noise levels is defined as an “acoustical change.” The numerical criteria used by the CAAC in defining an acoustical change is a change in certificated flyover, lateral or approach noise levels of 0.10 EPNdB/dB(A) (if such changes are not formally tracked by an CAAC approved method) or 0.30 EPNdB/dB(A) if an applicant has obtained an CAAC approved plan to track and sum cumulative changes. These criteria are also provided in section 1.4.3 of the appended ICAO TM and are established to limit the cumulative effects of multiple small changes.

(4) No Acoustical Changes: Type design changes that do not result in an “acoustical change” as defined in part 21, section 21.93(b) are referred to as “no acoustical changes” (NAC).

(5) NAC Cumulative Effects: When type design changes result in reduced noise levels, an applicant may elect not to provide the full part 36 substantiation, but instead provide CAAC with data and/or information to substantiate a NAC. However subsequent type design changes may require full part 36 certification because of cumulative acoustical effects. Example: An applicant proposes a configuration change which will reduce the noise levels by approximately 2.1 dB for the flyover noise measurement point, 1.1 dB for the lateral noise measurement point, and with no change in noise level at the approach noise measurement point. CAAC verifies that the noise levels were reduced, and the applicant accepts the pre-change configuration certificated noise levels as published in the AFM to apply to this change in type design. The applicant may not make another type design change as a NAC that increases the flyover noise level and the lateral noise level without providing substantiation of the cumulative effects of this type design change on AFM noise certificated levels. Multiple type design changes must be evaluated on a cumulative basis (as a combined single configuration) for each noise measurement point for the purposes of determining whether there is an acoustical change.

(6) Non-Standard Jet Airplane Configurations: Sections 21.93(b)(2)(i) and (ii) specify exceptions under which certain changes in jet airplane type design are not subject to compliance with 14 CFR part 36 requirements because such configurations are not intended for normal operations, but are typically required for maintenance operations (e.g., ferry flights, transporting engines to aircraft that cannot be ferried, etc.).

(7) Time-Limited Changes: Time-Limited engine or nacelle changes on jet airplanes for periods of up to 90 days (as specified in part 21, section 21.93(b)(2)

(iii)) may be necessary for continued airplane operation until maintenance can be performed on the original engines or nacelles that were changed. These changes must comply with applicable airworthiness standards and the maintenance, preventative maintenance, rebuilding and alteration inspection requirements of part 43. Such changes do not require compliance with part 36 requirements even though they may result in an increase in airplane noise levels, relative to the certificated noise levels. Section 21.93(b)(2)(iii) may only be used to intermix engines when maintenance is required and no conforming engine or nacelle for the configuration is available.

(8) Special Purpose Aircraft: Type design changes to propeller-driven small airplanes and helicopters do not need to comply with the provisions of part 36 when they are operated for special purposes as specified in part 21, sections 21.93(b)(3)(i-iv) and 21.93(b)(4).

c. Procedures

(1) Applicant's Responsibility: Pursuant to section 21.93(b), an applicant must identify type design changes that affect an aircraft's certificated noise levels by aircraft serial number and must demonstrate part 36 compliance for those aircraft. The noise levels approved by the CAAC for the modified aircraft must be documented in an CAAC Approved AFM or RFM by either a revision to the AFM or RFM (typically an option only available to the aircraft manufacturer), an AFM or RFM Supplement (for Supplemental Type Certificates and Field Approvals), or a Supplemental AFM or RFM (for aircraft that do not have a CAAC Approved AFM or RFM). Configurations and modifications for which noise approval is required must be found to comply with applicable airworthiness requirements specified in part 21 as well as the requirements of part 36 (reference section 36.3).

(2) NAC Approvals: CAAC may approve results of component laboratory demonstrations, back-to-back noise comparisons from ground tests or flight tests of each configuration, acoustical analyses, etc as acceptable for substantiating that an applicant's proposed changes to an aircraft type design is an NAC. The results from these evaluations must be applicable to an aircraft's certified noise levels at the part 36 reference noise measurement points.

17. Section 36.1(d) [Reserved]

18. Section 36.1(e) [Reserved]

19. Section 36.1(f)

For the purpose of showing compliance with this part for transport category large airplanes and jet airplanes regardless of category, the following terms have the following meanings:

(1) A "Stage 1 noise level" means a flyover, lateral or approach noise level greater than the Stage 2 noise limits prescribed in section B36.5(b) of appendix B of this part.

(2) A "Stage 1 airplane" means an airplane that has not been shown under this part to comply with the flyover, lateral, and approach noise levels required for Stage 2 or Stage 3 airplanes.

(3) A "Stage 2 noise level" means a noise level at or below the Stage 2 noise limits prescribed in section B36.5(b) of appendix B of this part but higher than the Stage 3 noise limits prescribed in section B36.5(c) of appendix B of this part.

(4) A "Stage 2 airplane" means an airplane that has been shown under this part to comply with Stage 2 noise levels prescribed in section B36.5(b) of appendix B of this part (including use of the applicable tradeoff provisions specified in section B36.6) and that does not comply with the requirements for a Stage 3 airplane.

(5) A "Stage 3 noise level" means a noise level at or below the Stage 3 noise limits prescribed in section B36.5(c) of appendix B of this part.

(6) A "Stage 3 airplane" means an airplane that has been shown under this part to comply with Stage 3 noise levels prescribed in section B36.5(c) of appendix B of this part (including use of the applicable tradeoff provisions specified in section B36.6).

(7) A "subsonic airplane" means an airplane for which the maximum operating limit speed, Mmo, does not exceed a Mach number of 1.

(8) A "supersonic airplane" means an airplane for which the maximum operating limit speed, Mmo, exceeds a Mach number of 1.

(9) A "Stage 4 noise level" means a noise level at or below the Stage 4 noise limit prescribed in section B36.5(d) of appendix B of this part.

(10) A "Stage 4 airplane" means an airplane that has been shown under this part not to exceed the Stage 4 noise limit prescribed in section B36.5(d) of

appendix B of this part.

(11) A "Chapter 4 noise level" means a noise level at or below the maximum noise level prescribed in Chapter 4, Paragraph 4.4, Maximum Noise Levels, of the International Civil Aviation Organization (ICAO) Annex 16, Volume I, Amendment 7, effective March 21, 2002.

20. Section 36.1(g)

For the purpose of showing compliance with this part for transport category large airplanes and jet airplanes regardless of category, each airplane may not be identified as complying with more than one stage or configuration simultaneously.

a. Explanation

This section specifies that each airplane configuration may be certificated to noise levels within the noise limits established for one stage only.

b. Supplemental Information

(1) In-flight Configuration Changes: In-flight changes in an airplane configuration (including changes in maximum gross weight) that could result in multiple certificated noise levels for a given noise measurement point or stage classification are not permitted. They are changes in the airplane type design and therefore require a change in operating limitations. A change in maximum gross weight requires an applicant to remove an airplane from service, and comply with the approval procedures of part 43.5 and 43.7. The type design approval procedures under part 21 must be followed if the change does not have prior certification approval.

c. Procedures

None

21. Section 36.1(h)

For the purpose of showing compliance with this part, for helicopters in the primary, normal, transport, and restricted categories, the following terms have the specified meanings:

(1) Stage 1 noise level means a takeoff, flyover, or approach noise level greater than the Stage 2 noise limits prescribed in section H36.305 of

appendix H of this part, or a flyover noise level greater than the Stage 2 noise limits prescribed in section J36.305 of appendix J of this part.

(2) Stage 1 helicopter means a helicopter that has not been shown under this part to comply with the takeoff, flyover, and approach noise levels required for Stage 2 helicopters as prescribed in section H36.305 of appendix H of this part, or a helicopter that has not been shown under this part to comply with the flyover noise level required for Stage 2 helicopters as prescribed in section J36.305 of appendix J of this part.

(3) Stage 2 noise level means a takeoff, flyover, or approach noise level at or below the Stage 2 noise limits prescribed in section H36.305 of appendix H of this part, or a flyover noise level at or below the Stage 2 limit prescribed in section J36.305 of appendix J of this part.

(4) Stage 2 helicopter means a helicopter that has been shown under this part to comply with Stage 2 noise limits (including applicable tradeoffs) prescribed in section H36.305 of appendix H of this part, or a helicopter that has been shown under this part to comply with the Stage 2 noise limit prescribed in section J36.305 of appendix J of this part.

(5) Maximum normal operating RPM means the highest rotor speed corresponding to the airworthiness limit imposed by the manufacturer and approved by the CAAC. Where a tolerance on the highest rotor speed is specified, the maximum normal operating rotor speed is the highest rotor speed for which that tolerance is given. If the rotor speed is automatically linked with flight condition, the maximum normal operating rotor speed corresponding with that flight condition must be used during the noise certification procedure. If rotor speed can be changed by pilot action, the highest normal operating rotor speed specified in the flight manual limitation section must be used during the noise certification procedure.

a. Explanation

None

b. Supplemental Information

(1) Helicopters Excepted: Helicopters that are designated exclusively for agricultural aircraft operations or for carrying external loads are excluded from the noise certification requirements.

(2) Stage 1/Stage 2: A helicopter, with a maximum take-off weight of

6000lbs (2,721kg) or less, that marginally fails to comply with the Stage 2 noise limit (by ~0.5 dB margin) prescribed in appendix J (section J36.305) has the alternative to comply with the Stage 2 noise limit of Appendix H (section H36.305).

Note: The Appendix J noise limit uses a sound exposure level (SEL) that was defined more stringent by approximately 2 dB than the corresponding average of the three Appendix H noise limits in EPNL. However, this is no guarantee that subsequent Appendix H noise certification testing will comply, especially for a military helicopter seeking civil certification.

c. Procedures

None

22. Section 36.2 Requirements as of date of application.

(a) As prescribed in §21.17 of CCAR-21, each person who applies for a type certificate for an aircraft covered by this part, must show that the aircraft meets the applicable requirements of this part that are effective on the date of application for that type certificate. When the time interval between the date of application for the type certificate and the issuance of the type certificate exceeds 5 years, the applicant must show that the aircraft meets the applicable requirements of this part that were effective on a date, to be selected by the applicant, not earlier than 5 years before the issue of the type certificate.

(b) As prescribed in §21.101(a) of CCAR-21, each person who applies for an acoustical change to a type design specified in §21.93 of CCAR-21 must show compliance with the applicable requirements of this part that are effective on the date of application for the change in type design. When the time interval between the date of application for the change in type design and the issuance of the amended or supplemental type certificate exceeds 5 years, the applicant must show that the aircraft meets the applicable requirements of this part that were effective on a date, to be selected by the applicant, not earlier than 5 years before the issue of the amended or supplemental type certificate.

(c) If an applicant elects to comply with a standard in this part that was effective after the date of application for a type certificate or change to a type design, the election:

(1) Must be approved by the CAAC;

(2) Must include standards adopted between the date of application and the date of the election;

(3) May include other standards adopted after the standard elected by the applicant as determined by the CAAC.

a. Explanation

Section 36.2 specifies the applicable part 36 requirements to be those in effect on the date of application for the a) aircraft type certificate or b) change in type design. If the time interval between application for the type certificate (or change in type design) and the issuance of the type certificate (or amended or supplemental type certificate) exceeds 5 years, the applicable part 36 requirements are those in effect, on a date to be selected by the applicant, not earlier than 5 years before the date of issuance of the type certificate, amended type certificate, or supplemental type certificate.

Section 36.2(c) permits the applicant to elect to demonstrate compliance with a later part 36 standard than is required by section 36.2(a) or (b). For the purposes of Section 36.2, "standard" refers to any of the requirements contained in part 36. As specified in sections 36.2(c)(1) and (2), an applicant's election of a later standard is subject to CAAC approval, and the election must include standards adopted between the date of application and the effective date of the standard that the applicant has elected to comply with. Thus, an applicant's election to demonstrate compliance with a particular later standard would also require that compliance be demonstrated with all other part 36 standards (applicable to the aircraft type) adopted between the date of application and the effective date of the standard that the applicant has elected to comply with. Further, in accordance with section 36.2(c)(3), the CAAC may require compliance with other standards that were adopted after the date of the elected standard. For the purposes of section 36.2(c)(3), "other standards" refers to other 14 CFR part 36 standards. For example, if the compliance standard elected under section 36.2(c)(3) had later been revised, the CAAC may determine that it is appropriate for compliance to be demonstrated with the revised standard. Such a determination would also require that compliance be demonstrated with all other part 36 standards (applicable to the aircraft type) adopted between the date of application and the effective date of the standard that the CAAC has determined to be the appropriate compliance basis.

b. Supplemental Information

None

c. Procedures

None

23. Section 36.3 Compatibility with airworthiness requirements

It must be shown that the aircraft meets the airworthiness regulations constituting the type certification basis of the aircraft under all conditions in which compliance with this part is shown, and that all procedures used in complying with this part, and all procedures and information for the flight crew developed under this part, are consistent with the airworthiness regulations constituting the type certification basis of the aircraft.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

(1) Aircraft certification tests and analyses must be conducted using configurations, procedures and information which are consistent with the airworthiness regulations applicable to that aircraft. For example, noise tests or analyses may not be conducted with landing flap settings which could not meet the applicable airworthiness regulation requirements.

24. Section 36.5 Limitation of part

The noise levels in this part have been determined to be as low as is economically reasonable, technologically practicable, and appropriate to the type of aircraft to which they apply. It shall be prescribed separately that these noise levels are or should be acceptable or unacceptable for operation at, into, or out of, any airport.

a. Explanation

This section specifies legal limitations regarding part 36.

b. Supplemental Information

(1) Scope of part 36 Regulation: Part 36 does not require compliance with noise standards related to aircraft operations, such as is provided in part 91. Part

36 certificated noise levels are achieved using procedures which can be duplicated practicably in normal operations by flight crews with safe reserves of thrust (power) and speed. CAAC prescribe standards to measure and evaluate aircraft noise. An original type certificate may be issued for an aircraft for which substantial noise abatement can be achieved. Consideration must be given to relevant information on aircraft noise, consultations with appropriate authorities, whether the standards or regulations are consistent with the highest degree of safety and are economically reasonable, technologically practical, and appropriate for the type of aircraft to which they apply.

c. Procedures

None

25. Section 36.6 Incorporations by reference

26. Section 36.6(a)

General. This part prescribes certain standards and procedures which are not set forth in full text in the rule.

27. Section 36.6(b)

Incorporated matter.

(1) Each publication, or part of a publication, which is referenced but not set forth in full-text in this part and which is identified in paragraph (c) of this section is hereby incorporated by reference and as a part of this part.

(2) Adoption of any subsequent change in incorporated matter is determined by CAAC based on the circumstances.

a. Explanation

This section specifies requirements for publications or documents to be "incorporated by reference" into part 36 and the process necessary when incorporated matter is subject to subsequent change.

b. Supplemental Information

None

c. Procedures

None

28. Section 36.6(c)

Identification statement. The complete title or description which identifies each published matter incorporated by reference in this part is as follows:

(1) International Electrotechnical Commission (IEC) Publications.

(i) IEC Publication No. 179, entitled "Precision Sound Level Meters," dated 1973.

(ii) IEC Publication No. 225, entitled "Octave, Half-Octave, Third Octave Band Filters Intended for the Analysis of Sounds and Vibrations," dated 1966.

(iii) IEC Publication No. 651, entitled "Sound Level Meters," first edition, dated 1979.

(iv) IEC Publication No. 561, entitled "Electro-acoustical Measuring Equipment for Aircraft Noise Certification," first edition, dated 1976.

(v) IEC Publication No. 804, entitled "Integrating-averaging Sound Level Meters," first edition, dated 1985.

(vi) IEC Publication 61094-3, entitled "Measurement Microphones—Part 3: Primary Method for Free- Field Calibration of Laboratory Standard Microphones by the Reciprocity Technique", edition 1.0, dated 1995.

(vii) IEC Publication 61094-4, entitled "Measurement Microphones—Part 4: Specifications for Working Standard Microphones", edition 1.0, dated 1995.

(viii) IEC Publication 61260, entitled "Electroacoustics-Octave-Band and Fractional-Octave-Band filters", edition 1.0, dated 1995.

(ix) IEC Publication 61265, entitled "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," edition 1.0, dated 1995.

(x) IEC Publication 60942, entitled "Electroacoustics—Sound Calibrators," edition 2.0, dated 1997.

(2) Society of Automotive Engineers (SAE) Publications.

(i) SAE ARP 866A, entitled "Standard Values at Atmospheric

Absorption as a Function of Temperature and Humidity for Use in Evaluating Aircraft Flyover Noise," dated March 15, 1975.

(3) International Standards and Recommended Practices, entitled "Environmental Protection, Annex 16 to the Convention on International Civil Aviation, Volume I, Aircraft Noise", Third Edition, July 1993,

a. Explanation

This section identifies standards and procedures that are incorporated by reference into part 36 as requirements for noise measurement and evaluation of various aircraft types.

b. Supplemental Information

(1) Other Publications. Other publications (see reference list of the appended ICAO TM) may be useful to an applicant during implementation of an aircraft noise certification process. Applicant proposals for use of standards and procedures found in these publications must be included in an applicant's noise compliance demonstration plan and approved by CAAC. An applicant should also contact a Specialist of Authority prior to submittal of a noise compliance demonstration plan to CAAC to determine whether there are new standards and procedures that are applicable to his particular aircraft noise certification process.

c. Procedures

None

29. [RESERVED]

30. [RESERVED]

31. Section 36.7 Acoustical Change: Transport category large airplanes and jet airplanes

32. Section 36.7(a)

Applicability.

This section applies to all transport category large airplanes and jet airplanes for which an acoustical change approval or validation is applied for under CCAR-21.

33. Section 36.7(b)

General requirements. Except as otherwise specifically provided, for each airplane covered by this section, the acoustical change approval or validation requirements are as follows:

(1) In showing compliance, noise levels must be measured and evaluated in accordance with the applicable procedures and conditions prescribed in Appendix A of this part.

(2) Compliance with the noise limits prescribed in section B36.5 of appendix B must be shown in accordance with the applicable provisions of sections B36.7 and B36.8 of appendix B of this part.

a. Explanation

This section specifies requirements for approval of acoustical changes applied for under part 21, section 21.93(b).

b. Supplemental Information

None

c. Procedures

None

34. Section 36.7(c)

Stage 1 airplanes. For each Stage 1 airplane prior to the change in type design, in addition to the provisions of paragraph (b) of this section, the following apply:

(1) If an airplane is a Stage 1 airplane prior to the change in type design, it may not, after the change in type design, exceed the noise levels created prior to the change in type design. The tradeoff provisions of section B36.6 of appendix B of this part may not be used to increase the Stage 1 noise levels, unless the aircraft qualifies as a Stage 2 airplane.

(2) In addition,

(i) There may be no reduction in power or thrust below the highest airworthiness approved power or thrust, during the tests conducted before and after the change in type design; and

(ii) During the flyover and lateral noise tests conducted before the

change in type design, the quietest airworthiness approved configuration available for the highest approved takeoff weight must be used.

a. Explanation

None

b. Supplemental Information

(1) Quietest Airworthiness Approved Configuration: This requirement was established to show that an acoustical change resulting from an approved type design change must be determined consistently. The CAAC policy does not require an applicant to determine the quietest airworthiness approved configuration at the flyover or lateral noise measurement points by noise measurement and evaluation. However, CAAC requires consistent evaluations between derivative and originally certificated configurations. For example, an applicant might choose an approved takeoff flap setting of 5 degrees. Later a type design change may be requested that would increase the flyover and lateral noise levels (an acoustical change). The CAAC may not require the applicant to measure and evaluate all airworthiness approved takeoff flap settings (e.g., 0, 1, 2, 5, 10 degrees) to determine the quietest configuration, but may, in this example, require appropriate evaluations for a flap setting of 5 degrees.

c. Procedures

None

35. Section 36.7(d)

Stage 2 airplanes. If an airplane is a Stage 2 airplane prior to the change in type design, the following apply, in addition to the provisions of paragraph (b) of this section:

(1) Airplanes with high bypass ratio jet engines. For an airplane that has jet engines with a bypass ratio of 2 or more before a change in type design:

(i) The airplane, after the change in type design, may not exceed either (A) each Stage 3 noise limit by more than 3 EPNdB, or (B) each Stage 2 noise limit, whichever is lower:

(ii) The tradeoff provisions of section B36.6 of appendix B of this part may be used in determining compliance under this paragraph with respect to the Stage 2 noise limit or to the Stage 3 plus 3 EPNdB noise limits, as applicable; and

(iii) During the flyover and lateral noise test conducted before the change in type design, the quietest airworthiness approved configuration available for the highest approved takeoff weight must be used.

(2) Airplanes that do not have high bypass ratio jet engines. For an airplane that does not have jet engines with a bypass ratio of 2 or more before a change in type design:

(i) The airplane may not be a Stage 1 airplane after the change in type design; and

(ii) During the flyover and lateral noise tests conducted before the change in type design, the quietest airworthiness approved configuration available for the highest approved takeoff weight must be used.

a. Explanation

None

b. Supplemental Information

See section 36.7(c), Supplemental Information, Item (1)

c. Procedures

None

36. Section 36.7(e)

Stage 3 airplanes. If an airplane is a Stage 3 airplane prior to the change in type design, the following apply, in addition to the provisions of paragraph (b) of this section:

(1) [Reserved]

(2) If compliance with Stage 3 noise levels is required before the change in type design, the airplane must be a Stage 3 airplane after the change in type design.

(3) [Reserved]

(4) If an airplane is a Stage 3 airplane prior to a change in type design, and becomes a Stage 4 after the change in type design, the airplane must remain a Stage 4 airplane.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

None

36A. Section 36.7(f)

Stage 4 airplanes. If an airplane is a Stage 4 airplane prior to a change in type design, the airplane must remain a Stage 4 airplane after the change in type design.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

None

37. Section 36.9 Acoustical change: Propeller-driven small airplanes and propeller-driven commuter category airplanes [To be completed later]

38. Section 36.9(a) [To be completed later]

39. Section 36.9(b) [To be completed later]

40. Section 36.11 Acoustical Change: Helicopters

This section applies to all helicopters in the primary, normal, transport, and restricted categories for which an acoustical change approval or validation is applied for under CCAR-21. Compliance with the requirements of this section must be demonstrated under appendix H of this part, or, for helicopters having a maximum certificated takeoff weight of not more than 3175 kg (7,000 pounds), compliance with this section may be demonstrated under appendix J of this part.

a. Explanation

None

b. Supplementary Information

(1) Modifications excluded from compliance with part 36, as listed in part 21, section 21.93(b)(4)(ii) Classification of Changes in Type Design:

(i) Addition or removal of external equipment; (This means 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 in operating or controlling a helicopter in flight and is not part of an airframe or engine).

(ii) Changes in the airframe made to accommodate the addition or removal to facilitate the use of external equipment, to provide for an external load attaching means, to facilitate the safe operation of the helicopter with external equipment mounted to, or external loads carried by, the helicopter;

(iii) Reconfiguration of the helicopter by the addition or removal of floats and skis;

(iv) Flight with one or more doors and/or windows removed or in an open position; or

(v) Any changes in the operational limitations on the helicopter as a consequence of the addition or removal of external equipment, floats, and skis, or flight operations with doors and/or windows removed or in an open position.

c. Procedures

None

41. Section 36.11(a)

General requirements.

Except as otherwise provided, for helicopters covered by this section, the acoustical change approval requirements are as follows:

(1) In showing compliance with the requirements of appendix H of this part, noise levels must be measured, evaluated, and calculated in accordance with the applicable procedures and conditions prescribed in parts B and C of appendix H of this part. For helicopters having a maximum certificated takeoff weight of not more than 3175 kg (7,000 pounds) that alternatively demonstrate compliance under appendix J of this part, the flyover noise level

prescribed in appendix J of this part must be measured, evaluated, and calculated in accordance with the applicable procedures and conditions prescribed in parts B and C of appendix J of this part.

(2) Compliance with the noise limits prescribed in section H36.305 of appendix H of this part must be shown in accordance with the applicable provisions of part D of appendix H of this part. For those helicopters that demonstrate compliance with the requirements of appendix J of this part, compliance with the noise levels prescribed in section J36.305 of appendix J of this part must be shown in accordance with the applicable provisions of part D of appendix J of this part.

a. Explanation

None

b. Supplementary Information

(1) Equivalent Procedures: Subject to prior approval by the CAAC, equivalent procedures may be used to measure, evaluate and calculate noise levels. Some commonly used equivalent procedures relating to helicopter noise certification will be included in a future revision to this AC.

(2) Noise Level Tradeoffs: Tradeoffs between the adjusted noise levels for flyover, takeoff and approach defined in H36.305(b) may be used to show compliance with the maximum noise levels (noise limits) of Appendix H. Since Appendix J only includes a flyover procedure, no tradeoff is possible.

c. Procedures

(1) Compliance: The procedure used to show compliance under Appendix H or Appendix J must follow the applicable parts of the regulation. Compliance with the maximum noise levels (noise limits) prescribed in section H36.305 of Appendix H or J36.305 of Appendix J must be shown.

42. Section 36.11(b)

Stage 1 helicopters.

Except as provided in §36.805(c), for each Stage 1 helicopter prior to a change in type design, the helicopter noise levels may not, after a change in type design, exceed the noise levels specified in section H36.305(a)(1) of appendix H of this part where the demonstration of compliance is under appendix H of this part. The tradeoff provisions under section H36.305(b) of

appendix H of this part may not be used to increase any Stage 1 noise level beyond these limits. If an applicant chooses to demonstrate compliance under appendix J of this part, for each Stage 1 helicopter prior to a change in type design, the helicopter noise levels may not, after a change in type design, exceed the Stage 2 noise levels specified in section J36.305(a) of appendix J of this part.

a. Explanation

None

b. Supplementary Information

(1) The maximum noise levels (noise limits) associated with a Stage 1 helicopter certificated under Appendix H after a change in type design are dependent on the noise levels of the original Stage 1 helicopter. Unless the Stage 1 helicopter after the change meets the Stage 2 maximum noise levels (noise limits), or Stage 2+ 2 EPNdB levels at each measuring point, it will be necessary to show that the helicopter has no increase in the noise levels at any of the measuring points. This will require determination of the noise levels associated with the original Stage 1 helicopter using Appendix H procedures. If this is not possible an applicant must obtain CAAC approval for another procedure.

c. Procedures

None

43. Section 36.11(c)

Stage 2 helicopters. For each helicopter that is Stage 2 prior to a change in type design, the helicopter must be a Stage 2 helicopter after a change in type design.

a. Explanation

None

b. Supplementary Information

(1) Helicopter under 3175 kg (7000 lbs): If after a change in type design a helicopter previously certificated under Appendix J, fails to meet the Appendix J Stage 2 maximum noise levels (noise limits) prescribed in J36.305 an applicant may attempt to show compliance by electing the use of Appendix H procedures and the Appendix H Stage 2 maximum noise levels (noise limits) specified in

H36.305.

(2) Noise Levels: Section 36.11 requirements apply to helicopters certificated under both Appendix H and Appendix J.

c. Procedures

None

44. -50. [RESERVED]

III. SUBPART B — TRANSPORT CATEGORY LARGE AIRPLANES AND JET AIRPLANES

a. Explanation

Subpart B specifies part 36 requirements for measurement and evaluation of airplane noise certification data, and maximum noise levels for Stage 1, Stage 2, Stage 3 and Stage 4 airplanes.

b. Procedures

None

c. Procedures

None

51. Section 36.101 Noise measurement and evaluation

For transport category large airplanes and jet airplanes, the noise generated by the airplane must be measured and evaluated under appendix A of this part or under an equivalent procedure approved by CAAC.

a. Explanation

None

b. Supplemental Information

(1) Appendix A: Appendix A prescribes methodologies for conducting noise certification tests and for measurement and evaluation of noise data for comparison with maximum noise levels specified in Appendix B (see Note A). Specific requirements include:

(i) Specifications of various physical and environmental conditions under which airplane noise certification measurements are permitted. These conditions are related to the noise test site, wind velocity/direction and atmospheric sound attenuation.

(ii) Procedures for measurement of atmospheric parameters.

(iii) Methods for synchronization of airplane position and performance measurements with noise measurements.

(iv) Specifications for noise certification measurement and analysis systems (See Note B).

(v) Methods to calculate atmospheric sound attenuation coefficients and Effective Perceived Noise Level (in units of EPNdB).

(vi) Methods for adjustment of measured flight test data to reference conditions.

(vii) Nomenclature for symbols and units.

(viii) Specification of data to be reported to FAA.

Notes:

(A) Appendix A requirements are nearly identical to those of Appendix 2 of Annex 16 Volume 1, Amendment 7 (See reference 11 of this AC).

(B) Some provisions of Appendix A may also apply to the noise certification of helicopters as prescribed in Appendix H of part 36.

(2) Equivalent Procedures: Equivalent Procedures, as referred to in this AC, are aircraft measurement, flight test, analytical or evaluation methods that differ from the methods specified in the text of part 36 Appendices A and B, but yield essentially the same noise levels. Equivalent procedures must be approved by the CAAC. Some equivalent procedures may be the same for all types of aircraft but others may be unique to specific types of aircraft or be proprietary to a particular aircraft manufacturer.

The appended ICAO TM provides both general and technical guidance on equivalent procedures that have been accepted as a technical means for demonstrating compliance with the noise certification requirements of ICAO Annex 16, Volume 1. Section 1 provides guidance material of a general nature including the purpose of the TM, its framework, information on incorporation of equivalent procedures and type design changes into compliance plans and changes to noise levels for derived versions. Section 2 contains technical guidance on equivalent and analytical procedures for subsonic jet airplanes, sections 3 and 4 contain similar guidance for propeller driven airplanes, and section 5 for helicopters. Technical guidance on evaluation procedures is given in section 6. The guidance material provided by the ICAO TM on equivalent procedures that have been approved in the past neither implies that they are the only acceptable ones, nor that they are limited for current noise certification applications, nor that CAAC has approved their application for any current or future aircraft noise certification actions (See Supplemental Information Items in Subpart O, section 1501, regarding the CAAC's approval process for equivalent procedures).

Notes:

(A) Flight test equivalent procedures have been used to acquire a sufficient number of noise measurements at various engine thrusts (powers) to develop generalized noise databases often referred to as Noise-Power-Distance (NPD) plots. (See section 2.1.2 and 3.1.2 of the appended ICAO TM). These NPD plots may be particularly useful for applicants to determine values of EPNLr for derived versions of an aircraft type.

(B) Equivalent procedures involving the use of static engine noise test data projected to flight conditions to account for changes to an airplane engine configuration or to an installation of an acoustically similar engine on the same airframe have been used for comparison to measured flight noise levels of the airplane with engines as originally certified. This type of data has also been used to demonstrate "no acoustical change" resulting from minor modifications to engine components. (See section 2.3 and 3.3 of the appended ICAO TM).

(C) Equivalent procedures involving analytical methods have been used to determine changes in airplane certificated noise levels resulting from thrust (power) reduction, modifications of airplane maximum takeoff or landing weights, engine thrust (power) rating changes, engine or nacelle configuration or acoustic treatment changes, and airplane performance changes resulting from airframe design changes. (See sections 2.2 and 3.2 of the appended ICAO TM).

c. Procedures

(1) Applicant's Responsibility: Applicants must prepare noise compliance demonstration plans for CAAC approval that include proposed methods for compliance with the requirements of Appendix B (See section B36.1). Equivalent procedure proposals in these plans must include substantiation of their technical validity and feasibility of application to the airplane type for which noise certification is requested. (See Subpart O section 1501, Supplemental Information, for noise compliance demonstration plan documentation requirements).

52. Section 36.103 Noise limits

53. Section 36.103(a)

For subsonic transport category large airplanes and subsonic jet airplanes compliance with this section must be shown with noise levels measured and evaluated as prescribed in appendix A of this part, and demonstrated at the

measuring points, and in accordance with the test procedures under section B36.8 (or an approved equivalent procedure), stated under appendix B of this part.

a. Explanation

This section specifies part 36 requirements for determination of EPNLr values.

b. Supplemental Information

(1) Noise Measurement Points: The locations of test noise measurement points frequently do not coincide with the reference noise measurement point locations specified in section B36.3. For example, locations of flyover noise measurement points may be subject to test site anomalies that would make it impractical to set up microphones at the reference locations. An applicant that has an approved equivalent procedure to measure airplane noise data for generation of NPD plots using the Flight Path Intercept procedure may select test noise measurement points (particularly the flyover point) so as to optimize the noise recording system signal-to-noise ratios.

(2) [RESERVED]

(3) Flight Test Guide: General approved flight test procedures, principles, methods and flight crew operational practices are included in Flight Test Guide (See reference 6 of this AC).

c. Procedures

None

54. Section 36.103(b)

Type certification applications before January 1, 2006, it must be shown that the noise levels of the airplane are no greater than the Stage 3 noise limit prescribed in section B36.5(c) of appendix B of this part.

a. Explanation

None

b. Supplemental Information

(1) Stage 3 Compliance: Transport category large airplanes and turbojet-powered airplanes, for which application for a type certificate was made

on or after November 5, 1975, are required to show compliance with Stage 3 maximum noise levels (noise limits) including tradeoffs. (See sections B36.5 and B36.6)

c. Procedures

None

54A. Section 36.103(c)

Type certification applications on or after January 1, 2006. If application is made on or after January 1, 2006, it must be shown that the noise levels of the airplane are no greater than the Stage 4 noise limit prescribed in section B36.5(d) of appendix B of this part. Prior to January 1, 2006, an applicant may seek voluntary certification to Stage 4. If Stage 4 certification is chosen, the requirements of §36.7(f) of this part will apply.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

None

54B. Section 36.105 Flight Manual Statement of Chapter 4 equivalency.

For each airplane that meets the requirements for Stage 4 certification, the Airplane Flight Manual or operations manual must include the following statement: "The following noise levels comply with CCAR-36, Appendix B, Stage 4 maximum noise level requirements and were obtained by analysis of approved data from noise tests conducted under the provisions of CCAR-36 (insert CCAR-36 Revision Number to which the airplane was certificated). The noise measurement and evaluation procedures used to obtain these noise levels are considered by the CAAC to be equivalent to the Chapter 4 noise level required by the International Civil Aviation Organization (ICAO) in Annex 16, Volume I, Appendix 2, Amendment 7, effective March 21, 2002."

a. Explanation

None

b. Supplemental Information

None

c. Procedures

None

IV. SUBPART C — [RESERVED]

V. SUBPART D — [RESERVED]

55. -57. [RESERVED]

VI. SUBPART E — [RESERVED]

VII. SUBPART F — PROPELLER-DRIVEN SMALL AIRPLANES AND PROPELLER-DRIVEN, COMMUTER CATEGORY AIRPLANES

No technical guidance has been developed for the following sections:

58. Section 36.501 Noise Limits

59. Section 36.501(a)

60. Section 36.501(b)

61. Section 36.501(c)

VIII. SUBPART G — [RESERVED]

62. -65. [RESERVED]

IX. SUBPART H — HELICOPTERS

66. Section 36.801 Noise measurement [To be completed later]

67. Section 36.803 Noise evaluation and calculation [To be completed later]

68. Section 36.805 Noise limits [To be completed later]

69. Section 36.805(a) [To be completed later]

70. Section 36.805(b) [To be completed later]

71. Section 36.805(c) [RESERVED]

72. Section 36.805(d) [To be completed later]

X. SUBPARTS I-N — [RESERVED]

73. -75. [RESERVED]

XI. SUBPART O — DOCUMENTATION, OPERATING LIMITATIONS AND INFORMATION

76. Section 36.1501 Procedures, noise levels and other information

77. Section 36.1501(a)

All procedures, weights, configurations, and other information or data employed for obtaining the certified noise levels prescribed by this part, including equivalent procedures used for flight, testing, and analysis, must be developed and approved. Noise levels achieved during type certification must be included in the approved airplane (rotorcraft) flight manual.

a. Explanation

This section specifies various types of information that must be developed and approved in the course of an aircraft (airplane or rotorcraft) noise certification process.

b. Supplemental Information

Noise Certification Compliance Documentation: The following types of documentation may be required in implementation of an aircraft (airplane of rotorcraft) noise certification process.

(1) NOISE CERTIFICATION PLANS: Applicant noise certification plans should be provided to CAAC in the early stages of an aircraft program and contain specific types of information including proposals for the methodology an applicant intends to use to certify a given type of aircraft. These plans, when approved, establish an aircraft's noise certification basis under part 36. When an aircraft program involves agreements between CAAC and foreign certificating authorities, these plans may specify an aircraft's noise certification basis under both part 36 and the noise regulation used by the foreign authority (e.g., ICAO Annex 16, Volume 1; JAR 36- See references 5 and 11 of this AC). An example would be aircraft certified under FAA/JAA Concurrent and Cooperative Programs (see Note).

Noise certification plans must include the following types of information:

(i) An overview of the contents of a forthcoming noise compliance

demonstration plan and noise certification report;

(ii) Description of applicable noise certification regulations and the tests, reports, data submittals and flight manual pages planned to complete an aircraft noise certification process;

(iii) Description of conformity requirements;

(iv) DERs and other cognizant personnel to be involved in the aircraft noise certification process;

(v) Milestone schedule of key events;

(vi) Miscellaneous information (e.g. acronyms, organizational codes, etc.).

Note: The FAA/JAA Concurrent and Cooperative Programs are intended to establish (to the extent possible) commonality in compliance methods and reduce program costs. Commonality may be achieved by obtaining approval from certificating authorities to use the most stringent requirements specified by the regulations involved, or by substantiating that the requirements of the regulations involved produce equivalent noise levels (in this case an applicant may choose a method of compliance from only one regulation).

(2) NOISE COMPLIANCE DEMONSTRATION PLANS (Aircraft Flight Test): Noise compliance demonstration plans contain the specific methodology (including equivalent procedures) by which an applicant proposes to establish compliance of a specific aircraft configuration with applicable part 36 requirements. These plans must define the information, data, and procedures that an applicant proposes in order to comply with the requirements of part 36. After approval by CAAC, flight tests specified in this plan are included as a part of the Type Inspection Authorization (TIA) used to fulfill requirements for TC, STC, and amended TC certification.

Noise compliance demonstration plans must include the following types of information:

(i) Introduction (Identify Applicable part 36 Requirements – Aircraft Noise Certification Basis);

(ii) Aircraft Description (Type, Model/Serial Numbers, Engines or Propellers Type, Model/Serial Numbers, Engine Ratings, Engine Nacelle Acoustic Treatments, Aircraft Gross Dimensions (including propeller and/or rotor diameter), Engine and ILS Antenna Locations, Aircraft/Engine

Conformity);

(iii) Noise Certification Methodology (Test Concepts and Equivalent Procedures - See sections 1.3, 2, 3, 4, or 5 of the appended ICAO TM), Plans for Determining Engine Spooldown Characteristics and Airframe Noise, Aircraft/Engine Performance Substantiation, Estimated Reference Conditions including Airspeeds, Thrust (Power) Reduction Distances, Altitudes, Thrust (Power) Settings, Methods for determination of EPNLr Values and 90% Confidence Limits, and Flight Manual Format;

(iv) Test Description: Test Site Location and Characteristics (e.g. Topography, Ground Cover and Obstructions), Location of Noise Measurement Points, Weather Constraints, Aircraft Configuration including Flap Settings, Airbrake and Landing Gear Positions, APU Operation, Conditions of Pneumatic Bleeds and Power/Take-Offs, Test Matrix, including Weights, Target Altitudes, Airspeeds, Engine Thrust (Power), and Test Tolerances;

(v) Measurement System Components and Procedures including Calibration Procedures: (Acoustical, Meteorological, Time/Space Position, Aircraft/Engine Performance);

(vi) Data Evaluation Procedures including Calibration and Data Processing (e.g., Approval Status of Data Processing Software and Version Level), Adjustment and Normalization Procedures: (Acoustical, Meteorological, Time/Space Position, and Airplane Engine Performance);

(vii) Aircraft Certification Schedule, including Noise Certification and TC Dates. Noise compliance plans should be submitted to FAA 60 days prior to start of testing. If new and novel equivalent procedures are proposed, or exemptions are required, then submittal of test plans earlier than 60 days prior to the start of testing may be necessary;

(viii) References;

(ix) A listing of all Equivalent Procedures utilized (e.g., Flight Path Intercept Procedure).

(3) NOISE COMPLIANCE DEMONSTRATION PLANS (Airplane Families): Noise certification of airplane families (derived versions) often require FAA approval of equivalent procedures involving measurement and evaluation of static engine noise test data as described in section 2.3 of the appended ICAO TM, in addition to the information listed in Item (2), above. These procedures include projection of static engine noise test data for

development of flyover, lateral, and approach NPD plots that define differences between the airplane used for the original noise certification flight test and a derived version (See Note 1). When use of static engine noise data is proposed, test plans must also be submitted to CAAC and either integrated into the basic noise compliance demonstration plan, or submitted to CAAC as separate plans and referenced in the basic plan.

Static engine noise test plans must include the following information:

(i) Engine Description (Type/Model and Serial Numbers, Nacelle Acoustic Treatments, Engine Conformity Requirements);

(ii) Test Description (Test Facility, Engine Installation, Turbulence Control Screen Configuration, Weather Constraints, Acoustical and Meteorological Measurement Points, Bleed Schedules, Test Run Matrix and Sequence including Thrust (Power) Settings and Test Tolerances);

(iii) Measurement System Components and Procedures including Calibration Procedures: (Acoustical, Meteorological, Engine Performance);

(iv) Data Evaluation Procedures including Calibration, Data Processing, Adjustment and Normalization Procedures (Acoustical, Meteorological, Engine Performance);

(v) Schedules (Static Noise Test, Noise Certification and TC dates);

(vi) References;

(vii) A listing of all Equivalent Procedures utilized.

Note 1: Applicants may also generate separate static test plans in cases where development of airplane families is anticipated but not yet formalized and there is opportunity to obtain static engine noise data (because of engine availability) for future noise certification applications.

(4) NOISE COMPLIANCE DEMONSTRATION PLANS (Analytical Methods): For certain aircraft type design changes (e.g. weight/thrust, airframe design changes and thrust (power) reduction distances or minor changes in engine components or acoustical treatments), applicants may propose using Analytical Equivalent Procedures to derive noise increments to an aircraft's certificated noise levels (See section 2.2, 3.2 or 5.13 of the appended ICAO TM) as applicable to the type of aircraft being certificated) or to demonstrate a no acoustical change (NAC) between the original certificated aircraft and the derived version.

Noise compliance demonstration plans must include the following information:

(i) Aircraft Description (Type/Model, Engines or Propellers) Type, Model/Serial Numbers;

(ii) Description of Type Design Changes;

(iii) Noise Certification Methodology (Overall Concepts, Description/Substantiation of Analytical Equivalent Procedures or Methods of Assessment of NAC Aircraft Reference Conditions, Methods for determination of EPNLr and 90% Confidence Limit values;

(iv) Aircraft Certification Schedules;

(v) References.

(5) DER "RAW DATA" REPORTS: FAA Order 8110.37C (reference 10 of this AC) specifies that Acoustical Designated Engineering Representatives (DERs) may, within the limits of their authority (defined in their letter of appointment) and with prior CAAC approval, witness noise certification tests conducted in accordance with CAAC approved noise compliance demonstration plans.

In cases where tests are witnessed by DERs, the CAAC may require the following information to validate that tests are being conducted in accordance with approved plans.

(i) Test Event Log (Includes Event Times and Conditions, Nominal Engine Thrusts (Powers) and Thrust (Power) Stability, Atmospheric Conditions, Airspeeds and Deviations Relative to Target Speeds, Valid and Invalid Test Points (including reasons for Invalid Points);

(ii) Test Measurement System Components (Type/Model) and Measurement/Calibration Procedures;

(iii) Measurement System Calibration Events and Results;

(iv) Measurement System Failures, Malfunctions, Non-Standard Operations, Spurious Signals and Corrective Actions Taken;

(v) Report of Test Condition Compliance with part 36 Test Site Requirements;

(vi) Field Data (Samples of Measured and Corrected Noise Spectra, Acoustical, Meteorological, Time/Space Position, Aircraft Performance Field

Data and Data Adjustments, EPNdB Estimates, and DER notes);

(vii) Summary of Meetings.

(6) NOISE CERTIFICATION REPORTS: Noise certification reports must provide information, data, and procedures demonstrating compliance with the requirements of part 36 and CAAC approved noise certification demonstration plans.

(7) NOISE CERTIFICATION REPORTS (Aircraft Flight Test): These reports must include the following:

(i) Introduction: Identify Applicable 14 CFR part 36 Requirements -- Aircraft Noise Certification Basis;

(ii) Aircraft Description: Type/Model/Serial Numbers, Engines or Propellers and Type, Model/Serial Numbers, Engine Ratings, Engine Nacelle Acoustical Treatments, Aircraft Gross Dimensions (including Propeller and/or Rotor diameter), Engine and ILS Antenna Locations, Aircraft/Engine Conformity Status, Reference Conditions (MTOW/MLW, Thrust (Power), Altitudes, Airspeeds, Takeoff Profiles);

(iii) Noise Certification Methodology: Noise certification methodology elements of a noise certification demonstration compliance plan approved by FAA for the aircraft configuration that is being certified and the specific report sections in which implementation of each element is addressed;

(iv) Test Description: Test Site Location and Characteristics (e.g. Topography, Ground Cover, and Obstructions), Location of Noise Measurement Points, Test Conditions for each Noise Measurement Point (including Weather), Aircraft Configuration e.g. Flap, Airbrake, Landing Gear and CG positions, APU Operation, Conditions of Pneumatic Bleeds and Power Takeoffs, Aircraft Weights, Altitudes, Airspeeds, Engine Thrust (Power), Engine Spooldown Measurement Points and Test Conditions, Airframe Noise Measurement Points and Test Conditions, and Valid and Invalid Measurements;

(v) Measurement System Components and Procedures including Calibration Procedures: Acoustical, Meteorological, Time/Space Position, Aircraft/Engine Performance Equipment;

(vi) Data Evaluation Procedures including Calibration, Data Processing and Adjustment Procedures: Acoustical, Meteorological, Time/Space Position, Aircraft/Engine Performance;

(vii) Data Analysis and Normalization Results: Analysis Results for Height of Maximum Lateral Noise, Thrust (Power) Reduction Distance, Airframe Noise Adjustments, Engine Spooldown Characteristics, Normalized Aircraft Data (e.g. Noise, Power, Distance Plots), Values of EPNLr and 90 % Confidence limits, and Aircraft Flight Manual Pages;

(viii) If test witnessing is delegated, then the witness log or notes specified in section 5 above must be included;

(ix) References.

(8) NOISE CERTIFICATION REPORTS (AIRPLANE FAMILIES): Noise certification reports involving airplane family concepts must include additional information on noise certification methodology and, if applicable, results of static engine noise tests as follows:

(i) Noise Certification Methodology: Identify Approved Equivalent Procedures for Projection of Static Engine Noise Data to Flight Conditions in NPD Plot Format and Methods for Defining: 1) NPD Plot Differences between Flight Datum (Originally Certified Airplanes) and Derived Versions, and 2) " Residual" NPD Plot Differences between Flight Test Data and Projected Flight Data for the Originally Certified Airplane;

(ii) Static Engine Noise Test Results;

(A) Engine Description (Type/Model/Serial Number, Nacelle Acoustic Treatments, Engine Conformity Status);

(B) Test Description (Test Facility, Engine Installation, Turbulence Control Screen, Acoustical and Meteorological Measurement Points, Bleed Schedules, Valid and Invalid test Points, Test Conditions for each Test Point (Weather, Engine Thrust (Power);

(C) Measurement Systems and Procedures Including Calibration Procedures: Acoustical, Meteorological and Engine Performance;

(D) Data Evaluation Procedures Including Calibration and Data Processing, Adjustment and Normalization Procedures: Acoustical, Meteorological, and Engine Performance.

(9) EQUIVALENT PROCEDURES: Applicants' proposals to use equivalent procedures must be included in aircraft noise compliance demonstration plans (See Note A). Such proposals may involve new procedures or procedures that have been used previously. However, applicants must be

capable of implementing proposed procedures and such procedures must be applicable to the specific aircraft model for which a TC is requested (See Note B). Equivalent procedures must be substantiated to yield the same noise levels as the procedures prescribed in part 36.

Although equivalent procedures are usually treated by the CAAC as proprietary property of an applicant, when several applicants propose closely related or similar procedures (e.g. Flight Path Intercepts), they may be considered to be common industry knowledge and may be described in this AC and/or the appended ICAO TM (See sections 2 through 6 of the appended ICAO TM).

Notes:

(A) Equivalent procedure proposals should be submitted to CAAC early in an aircraft noise certification program because approval may require more than one year.

(B) Prior to approving an equivalent procedure, the FAA must assess an applicant's capability to effectively implement the procedure as well as the appropriateness of the procedure for the specific type of aircraft for which certification is requested.

(C) The FAA is not authorized to approve alternate procedures or conditions as equivalent to the reference procedures (e.g., 3o approach glide path) or conditions specified in part 36.

(D) Data obtained during noise certification tests may support extrapolation of noise databases (e.g. for engine thrust (power) range extensions above and below what was tested). Guidance on extrapolation of NPD databases is provided in section 2.2.2 of the appended ICAO TM. Engine or aircraft designs that may cause transition to sonic fan tip velocity; mid-span fan shrouds interaction; fan exit guide vane choking; surge bleed valve operation; stator vane interaction; choked primary compressor entrance; increased inlet bypass airflow; change in aircraft configuration interaction, etc., may change the nature of the noise signature of the engine or aircraft and prevent an ordered extension of noise data. Static engine noise tests may not provide adequate proof that an extension of the noise database is valid. Guidance on generating increments to NPD databases is presented in section 2.2.2(c) of the appended ICAO TM based upon development of analytical noise models validated by certificating authorities.

(10) NO ACOUSTICAL CHANGE (NAC) DOCUMENTATION: Aircraft type design changes that are categorized as NAC require CAAC approval under the provisions of part 21 rather than part 36. Applicants' proposals for approval of NAC must be submitted to the CAAC in writing. The written submittal must define the planned changes in aircraft type design, and must include information, data and analyses that will substantiate that the specified type design change will not result in an "Acoustical Change" (See Subpart A, section 36.1(c), Supplemental Information (3).

NAC Substantiation documentation must include:

(i) Introduction (Concepts and Requirements)

(ii) Description of Aircraft Baseline and Proposed Type Design Changes

(iii) Methodology for Substantiating an NAC

(iv) Description of Tests and/or Analyses performed

(v) Test and/or Analyses Results Relating to Compliance with FAA NAC Criteria (See Subpart A section 36.1(c) Supplemental Information Item 3).

Notes:

(A) Part 21.93(b) states that, "…any voluntary change in the type design of an aircraft that may increase the noise levels of that aircraft is an 'acoustic change'." Therefore, NAC is determined on an aircraft by aircraft basis rather than just on the basis of the type certificate data sheet (TCDS) information for the aircraft model.

(B) Acoustic DERs may not determine that a type design change is an NAC.

c. Procedures

(1) Applicant's Responsibility: Applicants are responsible to generate and submit to CAAC the following noise certification documentation:

(i) Noise Certification Plans;

(ii) Noise Compliance Demonstration Plans (Including Proposed Equivalent Procedures);

(iii) Noise Certification Reports;

(iv) NAC Substantiation.

(2) DER'S Responsibility: Acoustic DERs responsibilities are as defined in FAA Order 8110.37C (reference 10 of this AC)

78. Section 36.1501(b)

Where supplemental test data are approved for modification or extension of an existing flight data base, such as acoustic data from engine static tests used in the certification of acoustical changes, the test procedures, physical configuration, and other information and procedures that are employed for obtaining the supplemental data must be developed and approved.

a. Explanation

The CAAC permits use of non-flight test data to supplement flight databases and to allow wider flexibility in the use of that data for aircraft modifications and extension of flight test data. This includes static engine noise test data used to modify or expand NPD databases for noise certification of derivative airplanes.

b. Supplemental Information

(1) Airplane Families: Section 2.3 of the appended ICAO TM presents guidance on static engine noise tests and projection of static engine noise data to flight conditions. Comparisons of projections of static engine noise data from the engines of an originally certified airplane with those of modified configuration engines could enable certification of modified configurations without further expensive and time consuming flight tests. (See section 36.1501(a), Supplemental Information Items (3) and (8)). An originally certified airplane and its derived versions are known as an "Airplane Family".

c. Procedures

(1) Tests For Supplemental Data: An applicant should attempt to obtain static engine or flight test noise data at engine thrust (power) settings and ranges, and airplane flight configurations and conditions that may be needed in the foreseeable future. This may necessitate over-boosting of the engine thrust (power) (with the permission of the engine manufacturer), resetting of the engine idle thrust (power) to lower limits, testing to higher or lower range of airspeed and angles of attack, testing at higher or lower altitudes, etc.

79. Section 36.1581 Manuals, markings, and placards

80. Section 36.1581(a)

If an Airplane Flight Manual or Rotorcraft Flight Manual is approved, the approved portion of the Airplane Flight Manual or Rotorcraft Flight Manual must contain the following information, in addition to that specified under §36.1583 of this part. If an Airplane Flight Manual or Rotorcraft Flight Manual is not approved, the procedures and information must be furnished in any combination of approved manual material, markings, and placards.

(1) For transport category large airplanes and jet airplanes, the noise level information must be one value for each flyover, lateral, and approach as defined and required by appendix B of this part, along with the maximum takeoff weight, maximum landing weight, and configuration.

(2) For propeller driven small airplanes, the noise level information must be one value for takeoff as defined and required by appendix G of this part, along with the maximum takeoff weight and configuration.

(3) For rotorcraft, the noise level information must be one value for each takeoff, flyover, and approach as defined and required by appendix H of this part, or one value for flyover as defined and required by appendix J of this part, at the maximum takeoff weight and configuration.

a. Explanation

This section specifies information that must be contained in airplane and rotorcraft flight manuals.

b. Supplemental Information

(1) An approved Airplane Flight Manual (AFM) or Rotorcraft Flight Manual (RFM) is required for certification of each aircraft type in compliance with section 1581 of the Airworthiness Standards for parts 21.24 (Primary Category), 23, 25, 27, and 29. Section 36.1581 of part 36 requires that certificated noise level compliance information be included in an AFM or RFM. These levels must be contained in an CAAC approved section of an AFM or RFM other than the limitations section. For example, the performance section is an appropriate place to include the certificated noise level compliance information. The certificated noise levels are to be reported to 0.1 dB in the AFM or RFM. Further, an AFM or RFM must specify the type certificate limitations if any, that are established as a result of part 36 compliance,

combined with the airworthiness limitations.

(2) Airplane Flight Manual Limitation Section:

(i) An AFM may be issued for a single airplane or a group of similar airplanes (including more than one series of a specific model). The AFM must clearly identify (by airplane serial number) the operating limitations, including the maximum weight limits that apply to an airplane.

(ii) The AFM may address a single configuration (hardware build) or multiple configurations. If an AFM includes information for more than one configuration (hardware build), the appropriate airplane operating limitations must be clearly identified for each configuration. Furthermore, if not all configurations are approved for the airplanes listed in the AFM, the AFM must clearly identify by serial number, the proper operating limitations for each airplane.

(iii) The operating limitations contained in the Limitations Section (including any noise-limited weights) must be expressed in mandatory language, not permissive language. The terminology used in the AFM must be consistent with the relevant regulatory language.

(3) Multiple Airplane Noise Certifications

(i) Multiple noise-limited gross weight pairs (takeoff and landing) for one airplane configuration are not permitted by Subpart A, section 36.1(g) for compliance with part 36. Only one set of gross weight limits that pertain to a particular configuration (hardware build) may be established under part 36 for a particular airplane.

(ii) An airplane configuration (hardware build) must be certificated to only a single “Stage” as appropriate under part 36 (Stage 1, Stage 2, or Stage 3). The limitations section of the AFM for an airplane configuration must not contain operating limitations that would result in noise levels exceeding part 36 noise limits. However, “Stage, 2” airplanes may be recertificated as “Stage 3”, provided AFMs are revised and approved for configurations appropriate for compliance with “Stage 3”, and the “Stage 2” approval is deleted.

(4) Landing Flap Restriction

(i) An operating limitation preventing the use of an approved landing flap setting cannot be imposed under part 36 and must be established under the airworthiness requirements or through a voluntary type design change. If such a

restriction is requested by an applicant in order to comply with part 36 certification requirements, that flap setting limit must be incorporated into the design and operation of the airplane.

(ii) For some Stage 3 airplanes, a “softguard” (such as a crushable cover plate) or frangible device must be installed on the flap selection control. This device makes obvious the flap settings that are not to be used for normal operation. Fracture or deformation of the softguard would indicate use of landing flap settings that have not been considered in demonstrating compliance with part 36. For airworthiness purposes, the design of these devices allows the flight crew use of airworthiness approved restricted flaps in emergencies (declared and undeclared). The device may not be resettable by the flight crew; a damaged softguard or frangible device must be repaired by a maintenance action accomplished in accordance with part 43 prior to the next flight.

c. Procedures

(1) Applicant Responsibility: An applicant must identify limiting configurations that may be required to satisfy airworthiness and/or noise regulatory requirements. The limiting configurations - including approved aircraft gross weights - are identified in the “Limitation Sections” of the approved aircraft AFM or RFM.

(2) Implementation of Landing Flap Restrictions: Long standing CAAC policy has resulted in a choice of two options for an applicant to implement landing flap restrictions, where their approval is consistent with applicable airworthiness requirements.

(i) Where permitted and possible, remove the cockpit flap selection control and performance information from the Performance Section of the original AFM that is relevant to flap settings not considered in demonstrating compliance with part 36

(ii) If flap settings not considered in demonstrating compliance with part 36 are to remain selectable then, to prevent their use in normal operations:

(A) Restrictions against their use, except under emergency (declared and undeclared) operations, must be incorporated into the AFM Limitations Section.

(B) Operational information must be relocated to the Emergency Procedures Section.

(C) For Stage 3 airplanes, install a “softguard” or frangible device over

the flap selection control.

D. Placards may be installed to provide appropriate information to the flight crew.

(3) ICAO Certifications: The CAAC is not authorized to approve aircraft compliance with Annex 16, Volume 1 Noise Standards. (reference 11 of this AC). This is the responsibility of the foreign airworthiness authority involved. CAAC participation is limited to witnessing tests and reviewing data. In those cases, where Stage 3 compliance has been demonstrated, it is permissible to insert the following statement in the AFM:

"Certification Noise Levels

The following noise levels comply with CCAR-36, Appendix B, Stage 3 noise level requirements and were obtained by analysis of approved data from noise tests conducted under the provisions of CCAR-36 (Insert part 36 amendment to which airplane was certificated). The noise measurement and evaluation procedures used to obtain these noise levels are essentially equivalent to those required by the International Civil Aviation Organization (ICAO) in Annex 16, Volume I, Chapter 3. ICAO Annex 16, Volume I, Chapter 3 approval is applicable only after endorsement by the Civil Aviation Authority of the country of airplane registration."

81. Section 36.1581(b)

If supplemental operational noise level information is included in the approved portion of the Airplane Flight Manual, it must be segregated, identified as information in addition to the certificated noise levels, and clearly distinguished from the information required under §36.1581(a).

a. Explanation

This section specifies requirements for including supplemental noise level information in an approved AFM.

b. Supplemental Information

(1) The CAAC permits publication of supplemental noise information in an approved AFM or RFM for configurations other the maximum takeoff and landing weight configuration or noisiest approach configuration. Such information may be useful to airlines in conjunction with their selection of operational route structures and airport operational requirements.

c. Procedures

(1) Applicant's Responsibility: Applicant's must identify supplemental noise levels as "Supplemental Information" when they are included in an AFM or RFM. Even though noise data used to provide "Supplemental Information" may have been obtained during certification noise testing and witnessed by the CAAC, it must still be clearly marked to show that it is not intended to demonstrate compliance with part 36, and may be presented in a non-CAAC approved section or page of the AFM or RFM.

82. Section 36.1581(c)

(c) The following statement must be furnished near the listed noise levels:

No determination has been made by the General Administration of Civil Aviation of China that the noise levels of this aircraft are or should be acceptable or unacceptable for operation at, into, or out of, any airport.

a. Explanation

This section specifies that the CAAC does not appraise aircraft in terms of their index of acceptability as related to airport operations.

b. Supplemental Information

Certification vs. Operational Rule: CCAR-36 is a certification rule and not an operational rule. The certificated noise levels may or may not meet the operational noise level requirements for any particular airport. The aircraft noise certification provisions of CCAR-36 do not place any operational permissibility or limitations on the operation of certificated aircraft at any airport.

c. Procedures

(1) Applicant's Responsibility: Applicants are responsible to develop an AFM or RFM and obtain CAAC approval prior to the aircraft entering service. The approved flight manual must list the certificated noise levels shown to comply with CCAR-36 maximum noise levels (noise limits) and contain a disclaimer as specified in section 36.1581(c).

83. Section 36.1581(d)

For transport category large airplanes and jet airplanes, for which the weight used in meeting the takeoff or landing noise requirements of this part

is less than the maximum weight established under the applicable airworthiness requirements, those lesser weights must be furnished, as operating limitations in the operating limitations section of the Airplane Flight Manual. Further, the maximum takeoff weight must not exceed the takeoff weight that is most critical from a takeoff noise standpoint.

a. Explanation

None

b. Supplemental Information

(1) Airworthiness Maximum Gross Weights: Transport category large airplanes and jet airplane gross weights are normally limited for structural, performance or economic reasons and demonstrated to the appropriate airworthiness standards for the airplane. Those airworthiness limited gross weights may constitute the maximum operational gross weights and are to be identified in the "Limitations Section" of an approved AFM.

(2) Approach Noise Limiting Configurations: Applicants may need to limit the landing flaps or the approach gross weight in order to comply with the requirements of part 36. All noise limiting gross weights and configurations are to be included in the "Limitations Section" of an approved AFM.

(3) Takeoff Noise Limiting Configurations: An applicant may establish takeoff limiting configurations (e.g., maximum takeoff gross weight, takeoff airspeed schedules, takeoff thrust (power) derate schedule, in-flight APU operation) that are more restrictive than the airworthiness limited configurations. These noise limited configurations are to be furnished in the Limitations Section of an approved AFM.

(4) Optional Engine Thrust (Power) Ratings (Derate and Reduced Thrust): Compliance with part 36 is only required at full rated takeoff thrust (power). However, an airplane may be type certificated at derated/reduced thrust (power) that is less than full rated takeoff thrust (power). This is not an acoustical change as defined in part 21 section 21.93(b) provided that the full rated thrust (power) remains approved for a given airplane configuration. Airplane type certification at derated/reduced thrust (power) does not prohibit an applicant from employing thrust (power) reduction for noise certification as permitted by section B36.7(b) of Appendix B.

c. Procedures

None

84. Section 36.1581(e)

For propeller driven small airplanes and for propeller-driven, commuter category airplanes for which the weight used in meeting the flyover noise requirements of this part is less than the maximum weight by an amount exceeding the amount of fuel needed to conduct the test, that lesser weight must be furnished, as an operating limitation, in the operating limitations section of an approved Airplane Flight Manual, in approved manual material, or on an approved placard.

85. Section 36.1581(f)

For primary, normal, transport, and restricted category helicopters, if the weight used in meeting the takeoff, flyover, or approach noise requirements of appendix H of this part, or the weight used in meeting the flyover noise requirement of appendix J of this part, is less than the certificated maximum takeoff weight established under either §27.25(a) or §29.25(a) of this chapter, that lesser weight must be furnished as an operating limitation in the operating limitations section of the Rotorcraft Flight Manual, in approved manual material, or on an approved placard.

86. Section 36.1581(g)

Except as provided in paragraphs (d), (e), and (f) of this section, no operating limitations are furnished under this part.

87. Section 36.1583 Noncomplying agricultural and fire fighting airplanes

88. Section 36.1583(a)

This section applies to propeller-driven, small airplanes that are designed for agricultural aircraft operations or for dispensing fire fighting materials.

a. Explanation

This section specifies the noise certification limitations and exemptions for propeller-driven, small airplanes that are specifically designed for agricultural aircraft operations or for dispensing fire fighting materials.

b. Supplemental Information

(1) Fire Fighting Airplanes: Those small propeller-driven airplanes that are specifically designed for “dispensing of fire fighting materials" are exempt from the noise certification requirements of part 36.

(2) Agricultural Airplane Operations: Agricultural aircraft operation means the operation of an aircraft for the purpose of:

(i) dispensing any economic poison, or

(ii) dispensing any other substance intended for plant nourishment, soil treatment, propagation of plant life, or pest control, or

(iii) engaging in dispensing activities directly affecting agriculture, horticulture, or forest preservation, but not including the dispensing of live insects.

(3) Economic Poisons: Economic poisons means:

(i) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or other animals, which the Secretary of Agriculture shall declare to be a pest, and

(ii) any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant.

c. Procedures

None

89. Section 36.1583(b)

For airplanes covered by this section an operating limitation reading as follows must be furnished in the manner prescribed in §36.1581:

Noise abatement: This airplane has not been shown to comply with the noise limits in “Noise Standards: Aircraft Type and Airworthiness Certification” (CCAR-36) and must be operated in accordance with the noise operating limitation prescribed under applicable operating regulations of CAAC.

a. Explanation

This section specifies an operating limitation that is to be included in an AFM for propeller-driven, small airplanes that are designed for agricultural operations and for dispensing fire fighting materials.

b. Supplemental Information

(1) Limitation on Operations: No person may operate an airplane that complies with the noise certification exemptions of this section, except:

(i) to accomplish the work activity directly associated with the purpose for which it is designed;

(ii) to provide flight crewmember training in the special purpose operation for which the airplane is designed; and

(iii) to conduct "nondispensing aerial work operations" related to agriculture, horticulture, or forest preservations.

c. Procedures

None

90. - 99 [RESERVED]

XII. APPENDIX A — AIRCRAFT NOISE MEASUREMENT AND EVALUATION UNDER § 36.101

100. Appendix A--Aircraft Noise Measurement and Evaluation Under § 36.101

Sec.

A36.1 Introduction.

A36.2 Noise certification test and measurement conditions.

A36.3 Measurement of aircraft noise received on the ground.

A36.4 Calculations of effective perceived noise level from measured data.

A36.5 Reporting of data to the FAA.

A36.6 Nomenclature: symbols and units.

A36.7 Sound attenuation in air.

A36.8 [Reserved]

A36.9 Adjustment of airplane flight test results.

a. Explanation

Appendix A addresses measurement and evaluation of noise generated by subsonic transport category large airplanes and jet airplanes. Helicopter noise measurement regulations are covered in Appendix H, unless otherwise noted within Appendix H.

b. Supplemental Information

None

c. Procedures

None

101. Section A36.1 Introduction

102. Section A36.1.1

This appendix prescribes the conditions under which airplane noise certification tests must be conducted and states the measurement procedures that must be used to measure airplane noise. The procedures that must be used to determine the noise evaluation quantity designated as effective perceived noise level, EPNL, under §§36.101 and 36.803 are also stated.

103. Section A36.1.2

The instructions and procedures given are intended to ensure uniformity during compliance tests and to permit comparison between tests of various types of airplanes conducted in various geographical locations.

104. Section A36.1.3

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 this appendix.

104A. Section A36.1.4

For Stage 4 airplanes, an acceptable alternate for noise measurement and evaluation is Appendix 2 to the International Civil Aviation Organization (ICAO) Annex 16, Environmental Protection, Volume I, Aircraft Noise, Third Edition, July 1993, Amendment 7, effective March 21, 2002.

105. Section A36.2. Noise certification test and measurement conditions

106. Section A36.2.1 General

107. Section A36.2.1.1

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

Note: Many noise certifications involve only minor changes to the airplane type design. The resulting changes in noise can often be established reliably without resorting to a complete test as outlined in this appendix. For this reason, the CAAC permits the use of approved equivalent procedures. There are also equivalent procedures that may be used in full certification

tests, 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 large airplanes is provided in the current advisory circular for this part.

a. Explanation

b. Supplemental Information

(1) Test Conditions: Appendix A of part 36 specifies test site requirements, noise measurement procedures and data evaluation procedures for airplane noise certification testing of subsonic transport category large airplanes and jet airplanes. The applicant may use equivalent procedures, subject to CAAC review and approval.

(2) Flight Path Intercept: The "flight path intercept" test procedure has been approved as an equivalent procedure wherein the airplane does not start from a static position on the airport runway for each flyover and lateral noise measurement (or land after each approach noise measurement), but remains in flight throughout the test series. See sections 2.1.1 and 3.1.1 of the appended ICAO TM. Stabilized airplane configuration and thrust (power) are maintained until it is determined that the measured noise level falls below PNLTM -10 dB. An A-weighted noise level is often used as a metric for determining this; noise measurement for a duration delimited by levels 15 dB (A) below the maximum A-weighted noise level is usually sufficient. The flight path intercept test procedure may be applied to all noise testing, including: flyover, lateral and approach noise measurements. This procedure saves valuable time by eliminating the takeoff, landing and turn-around for each measurement. This procedure also provides wider flexibility in the choice of test sites. The target airplane attitude, engine thrust (power), altitude over the microphones, constant configuration, etc., should be the same using the flight path intercept test procedure as it would be if the test were conducted from a standing start on the runway. See sections 2.1.1 and 3.1.1 of the appended ICAO TM for guidance on the use of the flight path intercept procedure.

(3) Equivalent Procedures: Equivalent procedures are discussed in sections 2 and 3 of the appended ICAO Technical Manual (TM). The procedure for obtaining CAAC approval of an equivalent procedure is discussed under section 36.101 of this AC. Equivalent procedures are also discussed in sections 36.1501, A36.5.3.1, A36.5.4.3, A36.9.1.2, B36.4 and B36.7(a) of this AC. Information on equivalent procedures is also provided in paragraph 6-3(e) of reference 7.

c. Procedures

(1) Applicant's Responsibility: An applicant must prepare a noise compliance demonstration plan that specifies a proposed certification process, including equivalencies. This plan is to be submitted to the appropriate noise specialist allowing sufficient calendar time (usually 2 months prior to the scheduled test) to permit adequate CAAC review and possible revisions prior to the start of any noise certification testing.

108. Section A36.2.2 Test environment

109. Section A36.2.2.1

Locations for measuring noise from an airplane in flight must 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 that significantly influence the sound field from the airplane must 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 obstruction.

a. Explanation

This section specifies the requirements for airplane noise certification test site characteristics to help ensure uniformity in the noise measurement process. It also describes the clear zone above and around the microphone station that must be free from obstructions that significantly influence the sound field from the airplane.

b. Supplemental Information

(1) Test Site Locations: When the flight path intercept test procedure is used, it may not be necessary for the test site to be located at an airport. Proposed noise certification test site locations must be submitted to the CAAC for review and approval. Some test site criteria that could support selection of a non-airport test site include: level terrain, reduced air traffic, reduced ambient noise, improved weather conditions (temperature, humidity and wind), improved microphone placement, availability of field surveys, improved locations for aircraft position monitoring, and improved pilot sight and handling.

(2) Noise Measurement Points: For the flyover, lateral and approach noise measurement points, 7.62-meter (25-foot) radius circles of mowed grass (not exceeding 3” in height) are acceptable. For the lateral measurement point, the grass may be mowed in a semicircle facing the line of flight.

(3) Snow: Snow in the area surrounding the noise measurement points may provide excessive absorption of airplane sound reflected from the ground. CAAC has approved noise measurements during winter conditions when snow within a 15.24-meter (50-foot) radius of the noise measurement points has been removed. However, snow must not be piled at the borders facing the line of flight.

(4) Plowed Fields: Earthen or sandy surfaces within a 7.62-meter (25-foot) radius of the noise measurement points must be reasonably tamped down. Plowed furrows, silt, or soft powdered surfaces are unacceptable.

(5) Obstructions: Obstructions in the vicinity of the noise measurement points such as buildings, walls, trees, vehicles, and test personnel (if close enough) may be unacceptable because of reflections that influence measured noise levels.

c. Procedures

(1) Applicant’s Responsibility: An applicant must identify the proposed test site characteristics in a proposed noise certification compliance demonstration plan.

110. Section A36.2.2.2

The tests must be carried out under the following atmospheric conditions.

a. Explanation

This section specifies the atmospheric conditions that are acceptable for airplane noise certification testing.

b. Supplemental Information

(1) Unacceptable Test Data: When testing is conducted outside the limits of atmospheric conditions specified in this section, valid adjustments from test to reference conditions may not be possible, and the data may not be acceptable.

c. Procedures

(1) Applicant’s Responsibility: The applicant is responsible for the

following:

(i) Specifying test atmospheric condition limits, meteorological measurement systems, calibration procedures, and data adjustment procedures in a noise compliance demonstration plan. See section A36.2.2.2(c) of this AC for more on atmospheric sound attenuation limits.

(ii) Instrumentation for the conduct of meteorological measurements.

(iii) Obtaining CAAC approval for deletion of any noise measurements that were obtained outside the approved limits of atmospheric conditions.

111. Section A36.2.2.2(a)

No precipitation.

a. Explanation

This subsection prohibits noise certification testing during conditions of rain or other precipitation. Rain and other precipitation (including fog, drizzle, snow) can affect the measurement system and sound propagation during noise measurements.

b. Supplemental Information

(1) Effects of Moisture on Microphones: Most microphones that are used during noise certification testing are susceptible to moisture. Precipitation, including snow, drizzle and fog, or excessive humidity may induce electrical arcing of the microphone sensors, making measured noise data unacceptable. However, some pre-polarized microphones are less susceptible to electrical arcing during high-moisture conditions (consult the equipment manufacturer's specifications). Special care must be taken to ensure that any windscreens exposed to precipitation be thoroughly dry, inside and out, before use. Foam windscreens can trap water; wet foam windscreens must be avoided.

(2) Microphone Internal Heaters: When internal heaters are provided, microphones are less likely to be affected by moisture in wet, humid, cold, or freezing atmospheric conditions.

c. Procedures

(1) Precautions: Special precautions must be taken by the applicant to protect microphones when a test shutdown is caused by wet, humid, or near freezing atmospheric conditions. Measurement System Components must be

thoroughly dry before testing is resumed, to prevent arcing.

112. Section A36.2.2.2(b)

Ambient air temperature not above 35 °C (95 °F) and not below −10 °C (14 °F), and relative humidity not above 95% and not below 20% over the whole noise path between a point 10 m (33 ft) above the ground and the airplane;

Note: Care should be taken to ensure that the noise measuring, airplane flight path tracking, and meteorological instrumentation are also operated within their specific environmental limitations.

a. Explanation

This subsection prescribes the ranges of ambient air temperature and relative humidity that are permitted during noise certification measurements. For each noise measurement, atmospheric temperature and relative humidity must be determined over the whole noise path between a location in the vicinity of the noise measurement points (at 10 meters above the ground) and the airplane. See section 6.4 of the appended ICAO TM.

b. Supplemental Information

(1) Assumed Ground Atmospheric Conditions: The temperature and relative humidity near the earth's surface can be affected by numerous factors, including solar heating, surface winds, local heating or cooling, increased or decreased local humidity, etc. To avoid localized anomalous conditions that often occur near the ground, meteorological measurements are to be made 10 m above the surface. During processing of acoustical data, the meteorological conditions measured at 10 m are assumed to be constant from that height down to the ground surface.

(2) Criteria for Measuring Atmospheric Conditions: Experience has shown that proper measurement of non-reference meteorological conditions, and the associated adjustment of noise data for those conditions, are crucial to obtaining accurate, consistent, and repeatable test results. Thus, meteorological observations of the temperature and relative humidity are required over the whole sound propagation path from the aircraft to the vicinity of the noise measurement points.

c. Procedures

(1) Atmospheric Measurements: Several methods have been approved for the measurement of atmospheric conditions from 10 m above the ground to the altitude of the test airplane. See section 6.4.2 of the appended ICAO TM. Some applicants have used instrumented unmanned model airplanes and balloons. The most common method consists of a manned meteorological airplane flown in a spiral flight path in the vicinity of the noise measurement points to measure the dry bulb temperature and dew point along the sound propagation path.

(2) Applicant's Responsibility: The applicant is responsible for providing the required meteorological measurement system that was approved in the noise compliance demonstration plan.

113. Section A36.2.2.2(c)

Relative humidity and ambient temperature over the whole noise path between a point 10 m (33 ft) above the ground and the airplane such that the sound attenuation in the one-third octave band centered on 8 kHz will not be more than 12 dB/100 m unless:

(1) The dew point and dry bulb temperatures are measured with a device which is accurate to ±0.9 °F (±0.5 °C) and used to obtain relative humidity; in addition layered sections of the atmosphere are used as described in section A36.2.2.3 to compute equivalent weighted sound attenuations in each one-third octave band; or

(2) The peak noy values at the time of PNLT, after adjustment to reference conditions, occur at frequencies less than or equal to 400 Hz.

a. Explanation

This subsection specifies limits on the atmospheric attenuation of sound at any point between 10 m above ground level and the altitude of the test airplane. These limits are applicable to each noise measurement

b. Supplemental Information

None

c. Procedures

None

114. Section A36.2.2.2(d)

If the atmospheric absorption coefficients vary over the PNLTM sound propagation path by more than ±0.5 dB/100m (±1.6 dB/1000 ft) in the 3,150Hz one-third octave band from the value of the absorption coefficient derived from the meteorological measurement obtained at 10 m (33 ft) above the surface, "layered" sections of the atmosphere must be used as described in section A36.2.2.3 to compute equivalent weighted sound attenuations in each one-third octave band; the CAAC will determine whether a sufficient number of layered sections have been used. For each measurement, where multiple layering is not required, equivalent sound attenuations in each one-third octave band must be determined by averaging the atmospheric absorption coefficients for each such band at 33 ft (10 m) above ground level, and at the flight level of the airplane at the time of PNLTM, for each measurement.

a. Explanation

This subsection specifies the use of layered sections of the atmosphere to adjust one-third-octave band sound pressure levels to reference conditions.

b. Supplemental Information

(1) When the use of multiple layered sections is required, the method to be used in defining the depth of the layered sections is specified in section A36.2.2.3 of this AC.

c. Procedures

(1) Section A36.2.2.3 provides examples that demonstrate the procedures for deriving atmospheric sound attenuation coefficients for the effects of atmospheric absorption when multiple layered sections are required.

(2) Example: The following example demonstrates the procedure for deriving the atmospheric sound attenuation coefficients when multiple layering is not required. The method for calculating values of atmospheric sound attenuation coefficients from meteorological data is specified in section A36.7.2 of this AC. During an approach noise certification flight test for a subsonic transport jet airplane, the following atmospheric measurements were recorded (interpolated from flight data and adjusted to PNLTM flyover time):

Table 1: Example – Atmospheric Measurements

Height, 10m (33ft)	Temperature, °F	RH, %	a (3150), dB/1000 ft
33 ft	71.0	65.5	5.54
100 ft	70.5	66.0	5.51

200 ft	68.4	63.0	5.48
300 ft	68.8	60.0	5.57
400 ft	67.5	56.0	5.79
500 ft	65.0	54.0	5.98

In this simplified example, the atmospheric sound attenuation coefficient (a3,150) over the sound propagation path varies less than the regulatory limit of 1.6 dB/1000 feet and therefore does not require use of multiple layers. The atmospheric sound attenuation coefficient for each one-third-octave band will be the average of the sound attenuation coefficients determined from the temperature and relative humidity data measured at 10m above the ground surface and at the airplane height, for maximum PNLT. Assuming an airplane test height of 400 feet, the average coefficient in the 3,150 Hertz band will be 5.67 dB/1,000 feet (i.e., the average of 5.54 and 5.79). The coefficients for the other one-third-octave bands are determined in a similar manner. These average coefficients are used to correct the measured data along the propagation path to the reference conditions for approach. The same general procedure would be used for determining atmospheric sound attenuation coefficients for take-off.

115. Section A36.2.2.2(e)

Average wind velocity 10 m (33 ft) above ground may not exceed 12 knots and the crosswind velocity for the airplane may not exceed 7 knots. The average wind velocity must be determined using a 30-second averaging period spanning the 10 dB-down time interval. Maximum wind velocity 10 m (33 ft) above ground is not to exceed 15 knots and the crosswind velocity is not to exceed 10 knots during the 10 dB-down time interval;

a. Explanation

This subsection specifies average and maximum wind velocity limits for noise certification testing.

b. Supplemental Information

None

c. Procedures

(1) Wind Limitations: The wind velocity limits throughout each noise measurement (PNLTM - 10 dB) taken at 10 m above the ground in the vicinity of the noise measurement points are as follows:

(i) Maximum wind velocity in any direction is not to exceed 28 km/h (15 knots)

(ii) Maximum crosswind velocity is not to exceed 18 km/h (10 knots)

(iii) Thirty-second average wind velocity in any direction is not to exceed 22 km/h (12 knots) and

(iv) Thirty-second average crosswind velocity is not to exceed 13 km/h (7 knots).

The CAAC ground observer and test witness should monitor these critical values. If at any time during a noise measurement these limits are exceeded, the measurement is to be declared invalid and will have to be repeated. The CAAC has not approved any method for making data corrections for wind velocity or direction.

(2) Wind Velocity Measurement: The average wind velocity must be determined on the basis of a 30 second average based on 1 second samples throughout the 10 dB-down period. The maximum wind velocity must be determined on the basis of a 1 second sample throughout the 10 dB-down period. (See section A36.2.2.4 for more on wind measurement.)

(3) Real-time Crosswind Measurements: Applicants are advised to provide approved real-time crosswind component measurement systems such that the crosswind speeds can be verified after each run. When the applicant uses a wind measurement system that is remotely located and not readily accessible, such as chart recorders that simultaneously and independently measure and record wind speed and direction, it may not be practical to determine the real-time crosswind component for each test run. If the applicant does not provide an acceptable real-time crosswind component measurement system, the 18 km/h (10-knot) and 13 km/h (7-knot) limitations specified under Wind Limitations for crosswind maximum and average limits become the maximum wind limitations regardless of wind direction.

116. Section A36.2.2.2(f)

No anomalous meteorological or wind conditions that would significantly affect the measured noise levels when the noise is recorded at the measuring points specified by the CAAC; and

a. Explanation

This subsection prohibits noise certification testing when anomalous wind conditions exist.

b. Supplemental Information

(1) Anomalous Winds: Compliance of measured wind velocities with the requirements of section A36.2.2.2(e) may not be sufficient to ensure that the wind velocities at the airplane altitude or along the sound propagation path are not excessive. Such conditions may exist as a steady head, tail or cross wind or as a wind from varying directions with increasing altitude. Anomalous winds may affect the handling characteristics of an airplane during a noise measurement period (also see section B36.8(g)). They also may affect the transmitted noise. Anomalous winds include not only gusts and turbulent winds, but also wind shear, strong vertical winds, and high crosswinds at the aircraft altitude and along the sound propagation path. An applicant may be required to measure winds aloft and provide the CAAC with the information. Acceptability of the wind conditions over the propagation path will be determined by the CAAC.

(2) Winds Aloft Measurement: Modern Inertial Navigation Systems (INS) and Differential Global Positioning Systems (DGPS) can provide on-board aircraft data that can be used to quantify winds aloft. The measurement of winds aloft can further be processed to provide a permanent record of wind velocity and direction.

(3) Effects of Wind on Airplane Control: The CAAC permits a ± 20 percent tolerance in overhead test altitude and a ±10° lateral tolerance relative to the extended runway centerline. If the flight crew cannot fly within the pretest-approved flight path tolerance limits, or experiences major variations in airspeed (see section B36.8(g)), or the airplane crabs or yaws significantly during the flight, adverse or anomalous wind conditions aloft are often the cause.

c. Procedures

(1) Flight Path: The flight crew must observe and record any occurrence where conditions aloft cause difficulty in maintaining the flight path or airspeeds, or when rough air in general makes the flight unacceptable. When the flight crew determines that such conditions are present, noise measurement should be terminated.

(2) Applicant’s Responsibility: When proposing a test site an applicant

must consider that certain geographical areas are more susceptible to anomalous wind conditions than others. The applicant may only conduct certification testing when approved by the CAAC.

117. Section A36.2.2.2(g)

Meteorological measurements must be obtained within 30 minutes of each noise test measurement; meteorological data must be interpolated to actual times of each noise measurement.

a. Explanation

This subsection specifies a requirement for measurement of atmospheric conditions within 30 minutes of each noise measurement.

b. Supplemental Information

(1) Upper Atmospheric Condition Measurements: Atmospheric conditions affect sound propagation; therefore, within 30 minutes of any noise measurement, temperature and relative humidity measurements from 10 m above the ground surface to the airplane test altitude at time of PNLTM must be made using an approved method. These measurements must be obtained and validated throughout the test period to ensure acceptable meteorological data for the noise data evaluation process.

c. Procedures

(1) Atmospheric Measurements: Applicants must consider the maximum altitude that will be attained within the next 60 minutes (or less) of testing to ensure that adequate upper atmospheric measurements are acquired. Interpolations for all noise measurements are made to airplane altitude at the time of PNLTM. To have sufficient meteorological data to perform the interpolation to the actual time of each noise measurement, the first meteorological measurement flight of the day should be made within 30 minutes before the first noise measurement; the last meteorological measurement flight of the day should be made within 30 minutes after the last noise measurement flight of the day.

(2) Atmospheric Data Interpolation: Either the time of airplane flight over the centerline noise measurement point or the time of attaining PNLTM is to be used as the interpolation time for each noise measurement.

118. Section A36.2.2.3

When a multiple layering calculation is required by section A36.2.2.2(c) or A36.2.2.2(d) the atmosphere between the airplane and 33 ft (10 m) above the ground must be divided into layers of equal depth. The depth of the layers must be set to not more than the depth of the narrowest layer across which the variation in the atmospheric absorption coefficient of the 3,150 Hz one-third octave band is not greater than ±1.6 dB/1000 ft (±0.5 dB/100m), with a minimum layer depth of 30 m (100 ft). This requirement must be met for the propagation path at PNLTM. The mean of the values of the atmospheric absorption coefficients at the top and bottom of each layer may be used to characterize the absorption properties of each layer.

a. Explanation

This section specifies criteria for defining the depth of layers and a method for determining the mean atmospheric sound attenuation coefficients when a multiple layering calculation is required for compliance with subsection A36.2.2.2(d).

b. Supplemental Information

None

c. Procedures

(1) Example: The following example demonstrates the procedure for deriving atmospheric sound attenuation coefficients when multiple layered sections are required. During an approach noise certification flight test for a subsonic transport jet airplane, the following atmospheric measurements were recorded (temperature and humidity interpolated to time of PNLTM flyover time):

Table 2: Example – Atmospheric Measurements

Height, 10m (33ft)	Temperature, °F	RH, %	a (3150), dB/1000 ft
33 ft	40.0	20.0	17.80
100 ft	39.0	20.0	17.30
200 ft	38.4	20.0	17.00
300 ft	38.0	19.0	16.26
400 ft	37.6	18.0	15.36
500 ft	37.0	18.0	14.93

In this example, the atmospheric sound attenuation coefficient (a3,150) over the sound propagation path varies by more than the limit of 1.6 dB/1,000

feet, requiring use of multiple layered sections. The example is based on the use of equal-depth layers, each being 100 feet, from the surface to the over-flight height, inclusive. The mean value of the atmospheric sound attenuation coefficients at the top and bottom of each layer is used to represent the atmospheric sound attenuation coefficient of the layer as follows:

Table 3: Example – Atmospheric Sound Attenuation Coefficients

Layer Height, ft	a (3,150), dB/1,000 ft
Ground to 100	17.55
100 to 200	17.15
200 to 300	16.63
300 to 400	15.81
400 to 500	15.15

The sound attenuation coefficient listed above for each layer would be used to obtain an average atmospheric sound attenuation coefficient to be applied in adjusting the measured one-third-octave band data (3,150 Hz) over the propagation path to reference conditions for approach. The coefficients for the other onethird-octave bands would be determined similarly. Procedure (2) under section A36.9.3.2.1 of this AC provides an example for obtaining the average atmospheric sound attenuation coefficient. This simplified example demonstrates the procedure used when multiple layers are required for determining the atmospheric sound attenuation coefficients used for data correction during approach testing. The procedures for determining atmospheric sound attenuation coefficients during take-off testing would be the same, although airplane test heights would be greater and the effects of atmospheric sound attenuation could be more significant. See explanation, supplemental information, and procedures under section A36.7 and A36.9.3.2.1 of this AC for information on determining and applying atmospheric sound attenuation adjustments.

119. Section A36.2.2.4

The airport control tower or another facility must be aproved by the CAAC for use as the central location at which measurements of atmospheric parameters are representative of those conditions existing over the geographical area in which noise measurements are made.

a. Explanation

This section specifies the requirement for approval of the location at which

meteorological measurements are obtained.

b. Supplemental Information

(1) Meteorological Measurements: Wind velocity, wind direction, crosswind velocity component, ambient temperature, and ambient relative humidity must be determined throughout the test period by an approved method. These data should be measured at a height of 10 m in the vicinity of the noise measurement points.

(2) Airport Measurement Systems: Airport (or other facility) meteorological facilities (located within a 1-mile distance from the noise measurement points) may be used for noise certification testing only if approved by the CAAC. Experience has indicated that there may be problems in approving these facilities because they normally do not include:

(i) Recent and acceptable calibrations of meteorological measurement systems.

(ii) Real-time recording systems that meet required sampling rates. The sampling rate should be at least one sample per second for wind velocity and wind direction and at least one sample per 10 seconds for temperature, relative humidity, and barometric pressure.

(iii) Meteorological measurement systems with adequate accuracy and response. The measurement systems used should meet the following minimum measurement tolerances:

(A) Wind Velocity: ±2.0 km/h (±1.1 knots) above 3.7 km/h (2.0 knots)

(B) Wind Direction: ±5 degrees

(C) Temperature: ±0.5 ºC (±1.0 ºF)

(D) Relative Humidity: ±3%

(E) Barometric Pressure: ±5 kPa (±104 psf).

In addition, the wind velocity and wind direction sensors should have a minimum operating threshold of 2.0 knots. The average wind velocity and wind direction data must be determined on the basis of a 30 second average (or averaging filter). Maximum wind speed values must be determined from 1-second samples of the instantaneous wind sensor output. The temperature, humidity, and barometric pressure sensors must have a response time of no greater than 10 seconds.

(iv) Meteorological measurement system components at the required height of 10 m above the ground.

c. Procedures

(1) Meteorological Measurements: Meteorological data are to be continuously measured and recorded at a height of 10 m above the ground in the vicinity of the noise measurement points throughout the 10 dB-down period.

(2) Applicant's Responsibility: Applicants must include a description of proposed meteorological measurement equipment for noise certification testing in a noise compliance demonstration plan.

120. Section A36.2.3 Flight path measurement

a. Explanation

This section specifies requirements for tracking the airplane position, synchronizing the airplane position with noise measurements, and ensuring that position and performance data are sufficient for adjustments of measured noise data to reference conditions.

b. Supplemental Information

None

c. Procedures

None

121. Section A36.2.3.1

The airplane height and lateral position relative to the flight track must 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 CAAC.

a. Explanation

This section specifies a requirement that the airplane's position in space be determined by an CAAC-approved method.

b. Supplemental Information

(1) Airplane Position Measurement: The CAAC has approved several methods for measurement of airplane position. Additional guidance is also

provided in section 6.5 of the appended ICAO TM. The CAAC has generally permitted any system that the applicant can use to accurately determine the airplane position relative to the extended runway centerline for each half-second throughout the 10 dB-down period noise measurement. Photographic scaling has been approved when the applicant can produce coordinated time sequencing airplane positions at three or more locations during the overflight. These can then be interpolated to identify the airplane position throughout the 10 dB-down period and can be used as evidence to show that the airplane was within the maximum lateral and height deviations during each half-second of the noise test. Guidance for obtaining CAAC approval of differential global positioning systems (DGPS) is available in VNTSC Letter Report DTS-75-FA753-LR3 (Reference 4 of this AC). FAA has also approved video camera systems in addition to the photo scaling methods. CAAC approval of airplane position measurement systems requires demonstrated accuracy and system documentation.

(2) Independent Airplane Position Determination: The CAAC will approve only those airplane position and altitude indicating and recording systems that are independent from the direct airplane flight path indicating systems. This restriction does not prohibit use of real time flight guidance systems (CDI/GDI) on board position systems, INS, Precision DMU and DGPS can provide guidance to the flight crew by providing the direct, real-time airplane position relative to the extended runway centerline. The data from such independent systems can be recorded to produce a time coordinated permanent record of each test.

c. Procedures

None

122. Section A36.2.3.2

The airplane position along the flight path must 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.

a. Explanation

This section specifies a requirement that airplane position data be synchronized with the noise measurements.

b. Supplemental Information

(1) Measurement System Synchronization: CAAC-approved airplane position and altitude indicating and measurement systems must be time synchronized with the noise measurement systems and meteorological measurement systems. The time synchronization between noise measurements and airplane position should be precise. A common time base must be used to synchronize noise, aircraft tracking, and meteorological measurements. Time-space-position information (TSPI) must be determined at half-second intervals throughout the sound-measuring period (within 10 dB of PNLTM) by an CAAC-approved method that is independent from systems installed aboard, and normally used to control, the airplane. During processing, measured TSPI data must be interpolated over time to the time of sound emission of each half-second acoustic data record within the 10 dB-down period. The time associated with each half-second record is 0.75 seconds before the end of each 2-second exponential averaging period (As defined in section A36.3.7.6). Although the simplified procedure requires adjustment of only the (PNLT) maximum record to the reference track, emission coordinates must be determined for each half-second record for use in background noise adjustment procedures and/or for determination of incidence-dependent free-field microphone and windscreen corrections.

(2) Measurement System Component Approval: Some off-the-shelf TSPI equipment may require software enhancement to accommodate the specific installation. Each applicant must submit information to the CAAC about the software used. CAAC will determine whether the software satisfies part 36 requirements. All TSPI equipment and software must be demonstrated to and approved by the CAAC to ensure the system's operational accuracy.

(3) Methods of Time Synchronization: Special care must be taken to properly synchronize acoustic data recordings with aircraft time-space-position information (TSPI) data. Specific methods, presented in order of preference, include:

(i) Continuous Time-Code Recording: This method uses a time-code signal, such as IRIG B, which is a modulated, audio-frequency signal used for encoding time-base data, developed by the Inter-Range Instrumentation Group (IRIG). In this method, the time-code signals from individual generators that have been synchronized to a common time-base are continuously recorded by both the noise data recorder(s) and by the TSPI system during measurement test runs. Synchronization of multiple generators can be performed physically (by

interconnecting via cable) or by means of radio transmission. The transmitted continuous time-code signal can be recorded directly, or used either continuously or in bursts to maintain synchronization of an independent time-code generator which is being recorded directly. This method allows for high-quality continuous time-code recording when there are intermittent reception problems.

(A) Synchronization must be accomplished at the start of each measurement day and checked at the end of each measurement day to minimize the effects of generator time drift. Any such drift must be documented and accounted for in processing.

(B) The use of Global Positioning System (GPS)-based measurement systems for acquisition of TSPI data is becoming commonplace. GPS receivers are capable of providing the user with precise time-base information (broadcast from the GPS satellite system), in some cases, eliminating the need for a separate time keeping device in the TSPI system. For noise data recording or for non-GPS-based-TSPI systems, dedicated IRIG B time-code generators are available that uses the GPS signal to constantly update and maintain time synchronization. Use of such a universal broadcast time-base can greatly simplify the logistics of time synchronization between measurement systems. It should be noted that there are two available time-bases for GPS-based systems, GPS Time and Coordinated Universal Time (UTC), whose values differ by more than 10 seconds at any given instant. Although the GPS signal includes both time bases, not all GPS receivers give the user access to both, therefore, the user should exercise caution in receiver selection.

(C) Many acoustical data recorders provide separate annotation channels in addition to the normal data channels. These channels are often not suitable for recording a modulated time-code signal because of limitations on dynamic range or bandwidth. In such cases, a normal data channel of the recorder must be dedicated to recording the time-code signal.

(D) When continuous time-code recording is used, analysis of the recorded acoustic data can be initiated by routing the time-code channel output into a time-code reader and triggering the analyzer based on readout time.

(ii) Recording of Single Time Marker: This method involves transmittal and recording of a radio "hack", or tone, usually used to indicate the "recorders on" or "overhead" time instant. This method typically requires a dedicated channel on both the noise and the TSPI recording systems. When such a system

is used, analysis can be triggered manually by an operator listening for the hack, or by a detector circuit responding to the tone. When the operator wishes to start analysis at a time other than that of the time marker, a stopwatch or delay circuit can be used to delay triggering of the analyzer. When manual triggering is employed, the operator must use extreme care to perform the triggering as accurately as possible. Accuracy to within one-tenth of a second can be expected from a conscientious human operator.

(iii) Measurement of Interval between Recorder Start and Overhead: This method of synchronization involves use of a stopwatch or elapsed-time indicator to measure the interval between start-up of the noise data recorder and the instant that the aircraft position is overhead of the centerline noise measurement point. This method can be employed successfully as long as (1) the operator exercises care in timing, (2) the determination of the overhead instant is performed accurately, and 3) the start-up characteristics of the recorder (in both record and playback modes) are known and repeatable. Some recorders have variable startup times that cannot be predicted. Such recorders are not suitable for this method of synchronization.

(iv) Setting of Internal Time-Stamp Clock: Many digital recorders maintain a continuous internal time-of-day function by encoding time data in the recorded data stream. This method uses a digital recorder's sub-code time, synchronized to the time-base used for the TSPI data. Unfortunately, the time-setting function on many recorders does not provide for the necessary precision. The "second" digits cannot be made to "tick" in synchrony with an external clock. Such recorders are unsuitable for this method of synchronization. As with the continuous time-code recording method, synchronization by this method must be checked at the beginning and end of each measurement day, and any drift accounted for in processing.

(4) Additional Time-Synchronization Considerations: Regardless of the synchronization method used, all elements affecting time synchronization (such as analyzer start-up delay, head displacement between normal and annotation data channels on analog recorders, delays in automated triggering circuits, etc.) must be identified, quantified, and accounted for in analysis and processing. Whenever human response to a timing event is required, errors cannot be accurately predicted, and conscientious operation is required to minimize such errors. The use of automated methods is preferred. Other methods, or variants of the listed methods may be appropriate, but the use of all methods and instrumentation is subject to prior approval by CAAC.

(5) 10 dB-down Period: This period is the portion of the airplane flyover in which the measured noise level is within 10 dB of PNLTM (i.e., the period to be used for the calculation of EPNL). Care should be taken during use of the flight path intercept method so that noise levels are outside the 10 dB-down period before flight path go-around procedures are initiated.

c. Procedures

None

123. Section A36.2.3.3

Position and performance data required to make the adjustments referred to in section A36.9 of this appendix must be automatically recorded at an approved sampling rate. Measuring equipment must be approved by the CAAC.

a. Explanation

This section specifies requirements for measuring sufficient airplane position and performance data to permit adjustments from test to reference conditions. See section 6.6 of the appended ICAO TM. These data must be measured and recorded in permanent form, and the measurement systems used to record data must be CAAC approved.

b. Supplemental Information

(1) Airplane and Engine Performance Parameters: Examples of parameters needed for measurement of airplane and engine performance include: airplane altitude, climb angle, airspeed and gross weight, flap position, landing gear position, engine thrust (power) setting parameters (e.g., compressor rotor speed, engine pressure ratio, exhaust gas temperature), and airplane accessory condition (e.g., A/C and APU "on" or "off"). Any other parameters that may affect measurement or adjustment of noise data and/or airplane or engine performance must also be recorded throughout the 10 dB-down period (e.g., SBV position, CG position).

c. Procedures

(1) Applicant's Responsibility: Aircraft performance parameters to be recorded and their range and tolerance should be proposed by an applicant in a noise compliance demonstration plan.

(2) Airplane Performance Measurements: Adequate airplane and engine

parameters are to be recorded during all certification testing to ensure that airplane performance can be accurately determined. For example, for transport airplanes this may necessitate measurement and recording of airplane flap position, landing gear position, speed brake position, APU operation, and normal engine thrust (power) setting and associated airplane flight parameters. Determination and recording of adequate information enables validation of the test airplane configuration and correction of airplane performance and engine performance from test conditions to part 36 acoustic reference day conditions.

(3) Recorder Sampling Rate: The measurements of airplane position, airplane airspeed, airplane performance and engine performance parameters are to be recorded at an approved sampling rate sufficient to permit adjustments from test to reference conditions throughout the 10 dB-down period. An acceptable recording sampling rate for transport category airplanes is two to five samples per second.

124. Section A36.3 Measurement of Airplane Noise Received on the Ground

125. Section A36.3.1 Definitions

For the purposes of section A36.3 the following definitions apply:

126. Section A36.3.1.1

Measurement system means 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 one-third octave band analysis system.

Note: 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.

127. Section A36.3.1.2

Microphone system means 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.

128. Section A36.3.1.3

Sound incidence angle means, in degrees, an angle between the principal axis of the microphone, as defined in IEC 61094-3 and IEC 61094-4, as amended and a line from the sound source to the center of the diaphragm of the microphone.

Note: 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".

129. Section A36.3.1.4

Reference direction means, 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.

130. Section A36.3.1.5

Free-field sensitivity of a microphone system means, in volts per Pascal, for a sinusoidal plane progressive sound wave of specified frequency, at a specified sound incidence 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.

131. Section A36.3.1.6

Free-field sensitivity level of a microphone system means, 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.

Note: The free-field sensitivity level of a microphone system may be determined by subtracting the sound pressure level (in decibels re 20 µPa) of the sound incident on the microphone from the voltage level (in decibels re 1V) at the output of the microphone system, and adding 93.98 dB to the result.

132. Section A36.3.1.7

Time-average band sound pressure level means, 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.

133. Section A36.3.1.8

Level range means, 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 must be rounded to the nearest decibel.

134. Section A36.3.1.9

Calibration sound pressure level means, 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.

135. Section A36.3.1.10

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

136. Section A36.3.1.11

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

137. Section A36.3.1.12

Level difference means, 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.

138. Section A36.3.1.13

Reference level difference means, 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.

139. Section A36.3.1.14

Level non-linearity means, 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.

140. Section A36.3.1.15

Linear operating range means, 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.

Note: Microphone extension cables as configured in the field need not be included for the linear operating range determination.

141. Section A36.3.1.16

Windscreen insertion loss means, 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.

a. Explanation

Sections A36.3.1.1 through A36.3.1.16 provide technical definitions of a total noise measurement system, its microphone system, and terms that relate to the acoustical performance characteristics of the measurement system and/or its components.

b. Supplemental Information

(1) Applicability: These definitions may be applicable to measurement systems used in noise certification of other types of aircraft (e.g., small airplanes and rotorcraft).

c. Procedures

(1) Applicant's Responsibility: An applicant's noise compliance demonstration plan must take these definitions into account in proposing measurement systems for use in noise certification.

142. Section A36.3.2 Reference environmental conditions

143. Section A36.3.2.1

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

(a) Air temperature 23 °C (73.4 °F);

(b) Static air pressure 101.325 kPa; and

(c) Relative humidity 50%.

a. Explanation

This section specifies the required environmental conditions that serve as reference for defining the performance of the measurement systems used for noise certification.

b. Supplemental Information

(1) These environmental specifications correspond to the recommended requirements of the International Electrotechnical Commission (IEC).

c. Procedures

None

144. Section A36.3.3 General

Note: Measurements of aircraft noise that are made using instruments that conform to the specifications of this section will yield one-third octave band sound pressure levels as a function of time. These one-third octave band levels are to be used for the calculation of effective perceived noise level as

described in section A36.4.

145. Section A36.3.3.1

The measurement system must consist of equipment approved by the CAAC and equivalent to the following:

(a) A windscreen (See A36.3.4.);

(b) A microphone system (See A36.3.5):

(c) A recording and reproducing system to store the measured aircraft noise signals for subsequent analysis (see A36.3.6);

(d) A one-third octave band analysis system (see A36.3.7); and

(e) Calibration systems to maintain the acoustical sensitivity of the above systems within specified tolerance limits (see A36.3.8).

a. Explanation

This section specifies the types of components required for a noise certification measurement system.

b. Supplemental Information

(1) Measurement System Criteria: The specifications for a measurement system allow flexibility in applicant procurement of measurement system components. While on-site EPNL analysis may be useful for estimation of recording levels or for other diagnostic purposes, a true acoustical analysis requires that data be recorded in the field. This will allow for later reanalysis or auditing of acoustic data. A recording also facilitates later off-line processing of acoustic data, including application of adjustments for items such as system frequency response, microphone pressure response, and analyzer bandwidth error. Recording simplifies synchronization with other pertinent data, such as tracking and meteorological measurements. Such synchronization is necessary for proper application of many of the required adjustments to acoustic data, for elements such as microphone free-field response, windscreen incidence-dependent insertion loss, the influence of ambient noise, high altitude jet noise effects, non-reference flight performance, and non-reference meteorological conditions. Proper implementation of such adjustments in the field would be extremely difficult.

(2) Approval of Measurement System: CAAC approval must be obtained

for systems used for measurement, recording, and analysis of aircraft noise. Most of the currently available system components that are appropriate for aircraft noise certification use have already been approved, but implementations of new technology and variants or upgrades of existing components may require evaluation by authorized organization before CAAC approval. Of special concern is the potential for a digital component's functionality to change as a result of firmware or operating system upgrades or modifications. Applicants should be aware that approval of a particular component might be version-dependent.

c. Procedures

(1) Validation of Measurement System Configuration: Each applicant must submit information to authorized organization about the measurement, recording, and analysis instrumentation and software used for CAAC approval.

(2) Changes in Measurement System Configuration: If an applicant makes changes to the approved instrumentation, the authorized organization must be notified before aircraft noise certification testing, to determine whether additional evaluation and CAAC approval are required.

146. Section A36.3.3.2

For any component of the measurement system that converts an analog signal to digital form, such conversion must be performed so that the levels of any possible aliases or artifacts 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 must be at least 28 kHz. An anti-aliasing filter must be included before the digitization process.

147. Section A36.3.4 Windscreen

148. Section A36.3.4.1

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 must not exceed ±1.5 dB at nominal one-third octave midband frequencies from 50 Hz to 10 kHz inclusive.

a. Explanation

This section specifies the methodology for determining windscreen

insertion loss and insertion loss tolerances for purposes of noise certification.

b. Supplemental Information

(1) Determination of Data Adjustments for Windscreen Insertion Loss: The physical condition of a windscreen can significantly affect its performance, and manufacturer-provided data for windscreen insertion loss are valid only for new or clean, dry windscreens. Insertion loss data adjustments for windscreens may be obtained by free-field calibration in an anechoic chamber.

c. Procedures

(1) Applicant's Responsibility: The applicant must specify proposed windscreen types and their insertion loss characteristics in a noise compliance demonstration plan.

149. Section A36.3.5 Microphone system

150. Section A36.3.5.1

The microphone system must meet the specifications in sections A36.3.5.2 to A36.3.5.4. Various microphone systems may be approved by the CAAC 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: An applicant must still calibrate and check each system as required in section A36.3.9.

151. Section A36.3.5.2

The microphone must be mounted with the sensing element 1.2 m (4 ft) above the local ground surface and must 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 must minimize the interference of the supports with the sound to be measured. Figure A36-1 illustrates sound incidence angles on a microphone.

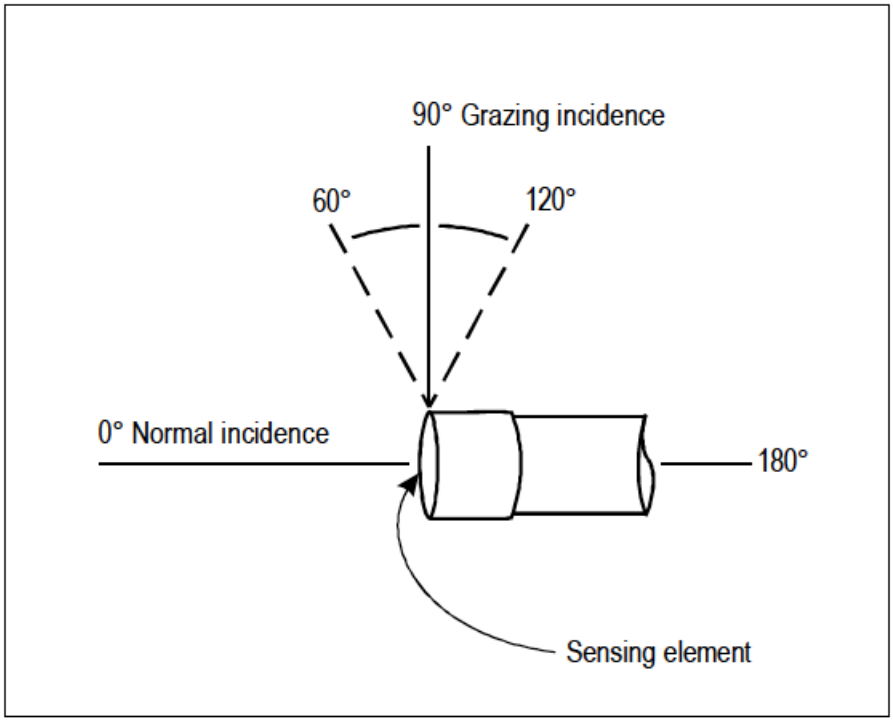


Figure A36-1: Illustration of Sound Incidence Angles on a Microphone

152. Section A36.3.5.3

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, must 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.

153. Section A36.3.5.4

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°, must 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 A36-1. The free-field sensitivity level differences at sound incidence angles between any two adjacent sound incidence angles in Table A36-1 must not exceed the tolerance limit for the greater angle.

Table A36-1. Microphone directional response requirements

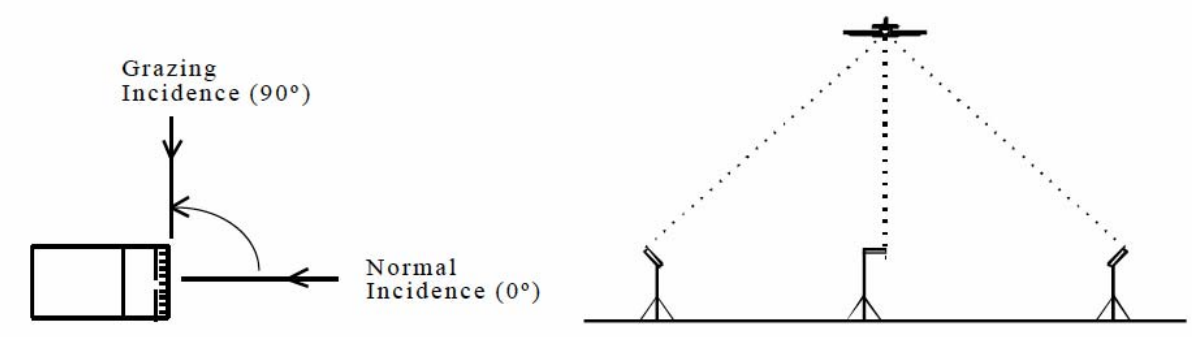
Nominal midband frequency kHz	Maximum difference between the free-field sensitivity level of a microphone system at normal incidence and the free-field sensitivity level at specified sound incidence angles (dB)				
	Sound incidence angle degrees				
	30	60	90	120	150
0.05 to 1.6	0.5	0.5	1.0	1.0	1.0
2.0	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

a. Explanation

This section specifies the required performance characteristics of microphone systems that may be used during noise certification testing.

b. Supplemental Information

(1) Grazing Incidence: The purpose of the grazing incidence specification is to minimize the effects of variations in the microphone response during measurement of airplane noise. By orienting the microphone so that the airplane is substantially within the plane of the microphone diaphragm (grazing incidence) during the 10 dB-down period, all sound from the airplane impinges on the microphone at approximately the same angle relative to its axis.



(2) Microphone Characteristics: These specifications are based on the performance characteristics of typical one-half-inch condenser microphones

designed for nearly uniform frequency response at grazing incidence. Other microphones may be used, provided they meet the specified performance requirements. For example, pre-polarized (electret condenser) free-field microphones exist that greatly minimize the possibility of arcing in humid environments and do not require an external polarization voltage. Although many of these microphones are intended primarily for use in normal-incidence free-field applications, they can be used in airplane noise certification testing if their performance at grazing incidence meets the requirements of section A36.3.5.

(3) Microphone Specifications: Table A36.1 specifies the maximum permitted differences between the free-field sensitivity of a microphone at normal incidence and the free-field sensitivity at specified sound incidence angles for sinusoidal sound waves at each one-third-octave-band nominal midband frequency over the range of 50 Hz to 10 kHz. These differences are larger at higher frequencies, allowing for the effect of the microphone body in a free-field environment.

c. Procedures

(1) Microphone Orientation: For microphones located directly under the flight path, an orientation angle of 90 degrees from vertical is appropriate regardless of target altitude. For lateral noise measurements, applicants may wish to reorient the microphones for grazing incidence for each target altitude in order to maintain substantially grazing incidence throughout the 10 dB-down periods. In many cases, this reorientation can eliminate the need to apply data adjustments for varying-incidence, since the incidence angles will be more likely to be contained within ± 30 degrees of grazing incidence.

(2) Applicant's Responsibility: The applicant must specify proposed microphone types and orientation for noise certification testing in a noise certification compliance demonstration plan.

154. Section A36.3.6 Recording and reproducing systems

155. Section A36.3.6.1

A recording and reproducing system, such as a digital or analog magnetic tape recorder, a computer-based system or other permanent data storage device, must be used to store sound pressure signals for subsequent analysis. The sound produced by the aircraft must be recorded in such a way

that a record of the complete acoustical signal is retained. The recording and reproducing systems must meet the specifications in sections A36.3.6.2 to A36.3.6.9 at the recording speeds and/or data sampling rates used for the noise certification tests. Conformance must be demonstrated for the frequency bandwidths and recording channels selected for the tests.

156. Section A36.3.6.2

The recording and reproducing systems must be calibrated as described in section A36.3.9.

(a) 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 must not exceed 20 dB relative to the gain at 800 Hz.

157. Section A36.3.6.3

For steady sinusoidal electrical signals applied to the input of the entire measurement system including all parts of the microphone system except the microphone 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 must be within ± 1.5 dB of that at the calibration check frequency. The frequency response of a measurement system, which includes components that convert analog signals to digital form, must be within ± 0.3 dB of the response at 10 kHz over the frequency range from 10 kHz to 11.2 kHz.

Note: Microphone extension cables as configured in the field need not be included for the frequency response determination. This allowance does not eliminate the requirement of including microphone extension cables when performing the pink noise recording in section A36.3.9.5.

158. Section A36.3.6.4

For analog 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 must not vary by more than ±0.5 dB throughout any reel of the type of magnetic tape used. Conformance to this requirement must be demonstrated using a device that has time-averaging properties equivalent to those of the spectrum analyzer.

159. Section A36.3.6.5

For all appropriate level ranges and for steady sinusoidal electrical signals applied to the input of the measurement system, including all parts of the microphone system except the microphone, 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 must not exceed ± 0.5 dB for a linear operating range of at least 50 dB below the upper boundary of the level range.

Note 1: Level linearity of measurement system components may be tested according to the methods described in IEC 61265 as amended.

Note 2: Microphone extension cables configured in the field need not be included for the level linearity determination.

160. Section A36.3.6.6

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

161. Section A36.3.6.7

The linear operating ranges on adjacent level ranges must overlap by at least 50 dB minus the change in attenuation introduced by a change in the level range controls.

Note: It is possible for a measurement system to have level range controls that permit attenuation changes of either 10 dB or 1 dB, for example. With 10 dB steps, the minimum overlap required would be 40 dB, and with 1 dB steps the minimum overlap would be 49 dB.

162. Section A36.3.6.8

An overload indicator must be included in the recording and reproducing systems so that an overload indication will occur during an overload condition on any relevant level range.

163. Section A36.3.6.9

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

a. Explanation

Sections A36.3.6.2 through A36.3.9 specify the performance characteristics required for a recording and reproducing system used to store airplane noise signals recorded during noise certification testing for subsequent analysis.

b. Supplemental Information

(1) Recorder Types: An applicant has a choice of recorder types that will satisfy the CAAC requirement for recording "the complete acoustic signal" during certification testing. In addition to a magnetic tape recorder, other means of obtaining a "true" acoustic recording include digital audiotape (DAT), recordable compact disc (CD-R), and direct-to-hard-disk recording. The applicant should be aware that systems that use data compression techniques that result in substantial data loss, such as Mini-Disc (MD) or digital compact cassette (DCC), are not acceptable.

c. Procedures

(1) Frequency Range for Recordings: The time-varying waveform produced by the microphone response to noise signals during certification tests must be recorded. If there are questions about the data observed during the tests, the recording can be replayed, multiple times if necessary, to verify the results. Recorded data, whether digital or analog in nature, must allow reproduction and reprocessing of an analog signal over the frequency range of 40 Hz to 12.6 kHz. A dynamic range of at least 60 dB is recommended. Many typical instrumentation DAT recorders feature a nominal 10 kHz bandwidth operating mode in which the attenuating response of the antialiasing filter intrudes within the 10 kHz one-third-octave passband. In such cases, the recorder must be operated in a nominal 20 kHz-bandwidth mode, which may reduce the number of available channels or the duration of available time per tape.

Note: Although the one-third-octave bands of interest are those with nominal center frequencies of 50 Hz through 10 kHz, to ensure that the entire

actual bandwidth of the uppermost and lowermost bands is included, the center frequencies of the one-third-octave bands immediately outside this range are specified.

(2) Digital Recording Levels: The overload characteristic of a digital system is determined primarily by the limits of the analog-to-digital-conversion. Since such an overload condition is characterized by an abrupt, catastrophic type of distortion, the level range should be set so that the anticipated maximum signal level is at least 10 dB, and preferably 20 dB, below the upper boundary of the linear operating range.

(3) Dynamic Range Limits-Digital Recorders: The lower limit of a digital recording system's usable dynamic range is more often determined by amplitude non-linearity (due primarily to "quantization error") than by the presence of a noise floor. Digital devices (such as recorders or analyzers) that are to be used for aircraft noise certification purposes must be tested to determine the extent of such non-linearity.

(4) Consider a 16-Bit Quantization System: The theoretical dynamic range of such a system is usually assumed to be near 96 dB (i.e., 20×log10 (2^16)). At the lower limit of this range, there is a potential for 6 dB error in the digitized signal versus the analog input signal that it represents. IEC 61265 imposes a ±2.0 dB limit on acceptable linearity error outside of an instrument's linear operating range. As amplitude levels are increased above the lower quantization limit, the linearity error is reduced. If the guidance for setting the level range is followed, the usable dynamic range is further decreased. Significant improvement of amplitude linearity can be obtained by system designers via implementation of techniques such as over-sampling and dithering. Therefore, testing must be performed to determine the actual limits for each digital recording system. Assumptions based on experience with analog systems do not always apply.

(5) Pre-emphasis Systems: Use of pre-emphasis will only be allowed if the system also employs complementary de-emphasis. Attempts to compensate for the effects of a pre-emphasis filter by applying onethird-octave-band de-emphasis adjustments (either numerically to analyzed data via a pink noise correction or on a band-by-band basis using separate gain stages for each one-third-octave-band filter) are not allowed. In addition, use of a pre-emphasis/de-emphasis system will require testing and documentation of all filters and gain stages involved to ensure that any errors are quantified and minimized, and that the system performs predictably and reliably.

(6) Attenuator Specification: This requirement allows for the use of switchable voltage input range settings (now commonplace on DAT recorders) as controllable attenuation steps for gain-setting purposes. In all cases, attenuators must have fixed repeatable steps. Any devices in the measurement system that use vernier or continuously–adjustable gain controls must also have some demonstrable means of being fixed, or locked at a specific setting to eliminate non-traceable gain errors.

164. Section A36.3.7 Analysis systems

165. Section A36.3.7.1

The analysis system must conform to the specifications in sections A36.3.7.2 to A36.3.7.7 for the frequency bandwidths, channel configurations and gain settings used for analysis.

166. Section A36.3.7.2

The output of the analysis system must 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 must be 500 ms ± 5 milliseconds (ms) for spectral analysis with or without slow time-weighting, as defined in section A36.3.7.4;

(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 analyzer, the loss of data must not exceed a duration of 5 ms; and

(e) The analysis system must operate in real time from 50 Hz through at least 12 kHz inclusive. This requirement applies to all operating channels of a multi-channel spectral analysis system.

167. Section A36.3.7.3

The minimum standard for the one-third octave band analysis system is the class 2 electrical performance requirements of IEC 61260 as amended, over the range of one-third octave nominal midband frequencies from 50 Hz through 10 kHz inclusive.

Note: IEC 61260 specifies procedures for testing of one-third octave band analysis systems for relative attenuation, anti-aliasing filters, real time operation, level linearity, and filter integrated response (effective bandwidth).

168. Section A36.3.7.4

When slow time averaging is performed in the analyzer, 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, must be measured at sampling instants 0.5, 1, 1.5 and 2 seconds(s) after the onset and 0.5 and 1s after interruption. The rising response must be −4±1 dB at 0.5s, −1.75±0.75 dB at 1s, −1±0.5 dB at 1.5s and −0.5±0.5 dB at 2s relative to the steady-state level. The falling response must be such that the sum of the output signal levels, relative to the initial steady-state level, and the corresponding rising response reading is −6.5 ±1 dB, at both 0.5 and 1s. At subsequent times the sum of the rising and falling responses must be -7.5 dB or less. This equates to an exponential averaging process (slow time-weighting) with a nominal 1s time constant (i.e., 2s averaging time).

169. Section A36.3.7.5

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

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

where $L_s(i,k)$ is the simulated slow time-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 analyzer for the k-th instant of time and i-th

one-third octave band. For k=1, the slow time-weighted sound pressure Ls[i,(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:

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

where L_s(i,k) is the simulated slow time-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 analyzer 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 0.5s 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 time-weighted sound pressure levels from samples of 0.5 seconds time average sound pressure levels. The equations do not work with data samples where the averaging time differs from 0.5 seconds.

170. Section A36.3.7.6

The instant in time by which a slow time-weighted sound pressure level is characterized must 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 time-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 seconds averaging period.

171. Section A36.3.7.7

The resolution of the sound pressure levels, both displayed and stored, must be 0.1 dB or finer.

a. Explanation

This section specifies the required performance characteristics of an

analysis system for use in airplane noise certification.

b. Supplemental Information

(1) Analyzer Specifications: IEC 61260 specifies the Class 2 electrical performance requirements of one-third-octave-band filters, including tolerances for the attenuation in the transition bands ("skirts") adjacent to the one-third-octave pass-bands. Most digital one-third-octave-band analysis systems offer only hardwired filtering algorithms that emulate the response of a traditional third-order analysis filter having a maximally-flat pass-band. However, some analysis systems allow the selection of other filtering algorithms which might not provide equivalent performance. CAAC policy requires an applicant to demonstrate the effects that alternate filter design response characteristics might have on noise certification EPNL values.

(2) Determination of Bandwidth Error Corrections: The manufacturer can establish the geometric center frequencies of one-third-octave-band filters using either Base 2 or Base 10 systems. While the use of either method results in frequencies close to the nominal center frequencies referred to in part 36, it is important to note which system is used so that the bandwidth error adjustment can be properly determined. Use of test frequencies calculated by a different base-number system than that for which the analyzer was designed can result in erroneous values for these adjustments.

(3) Externally Controlled Linear-Integrating Analyzers: In cases where a computer or other external device is used to control and/or communicate with an analyzer performing linear integration, extra care should be taken to ensure that the integration period requirements are met. Some analyzers from major manufacturers have required factory modification in order to provide an integration time within 5 milliseconds of the specified 500-millisecond integration period.

c. Procedures

None

172. Section A36.3.8 Calibration systems

173. Section A36.3.8.1

The acoustical sensitivity of the measurement system must be determined using a sound calibrator generating a known sound pressure level at a known

frequency. The minimum standard for the sound calibrator is the class 1L requirements of IEC 60942 as amended.

174. Section A36.3.9 Calibration and checking of system

175. Section A36.3.9.1

Calibration and checking of the measurement system and its constituent components must be carried out to the satisfaction of the CAAC by the methods specified in sections A36.3.9.2 through A36.3.9.10. The calibration adjustments, including those for environmental effects on sound calibrator output level, must be reported to the CAAC and applied to the measured one-third-octave sound pressure levels determined from the output of the analyzer. Data collected during an overload indication are invalid and may not be used. If the overload condition occurred during recording, the associated test data are invalid, whereas if the overload occurred during analysis, the analysis must be repeated with reduced sensitivity to eliminate the overload.

176. Section A36.3.9.2

The free-field frequency response of the microphone system may be determined by use of an electrostatic actuator in combination with manufacturer's data or by tests in an anechoic free-field facility. The correction for frequency response must be determined within 90 days of each test series. The correction for non-uniform frequency response of the microphone system must be reported to the CAAC and applied to the measured one-third octave band sound pressure levels determined from the output of the analyzer.

177. Section A36.3.9.3

When the angles of incidence of sound emitted from the aircraft are within ± 300 of grazing incidence at the microphone (see Figure A36-1), a single set of free-field corrections based on grazing incidence is considered sufficient for correction of directional response effects. For other cases, the angle of incidence for each one-half second sample must be determined and applied for the correction of incidence effects.

178. Section A36.3.9.4

For analog magnetic tape recorders, each reel of magnetic tape must carry at least 30 seconds of pink random or pseudo-random noise at its beginning and end. Data obtained from analog tape-recorded signals will be accepted as reliable 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.

179. Section A36.3.9.5

The frequency response of the entire measurement system while deployed in the field during the test series, exclusive of the microphone, must be determined at a level within 5 dB of the level corresponding to the calibration sound pressure level on the level range used during the tests for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive, utilizing pink random or pseudo-random noise. Within six months of each test series the output of the noise generator must be determined by a method traceable to an organization recognized by the CAAC. Changes in the relative output from the previous calibration at each one-third octave band may not exceed 0.2 dB. The correction for frequency response must be reported to the CAAC and applied to the measured one-third octave sound pressure levels determined from the output of the analyzer.

180. Section A36.3.9.6

The performance of switched attenuators in the equipment used during noise certification measurements and calibration must be checked within six months of each test series to ensure that the maximum error does not exceed 0.1 dB.

181. Section A36.3.9.7

The sound pressure level produced in the cavity of the coupler of the sound calibrator must be calculated for the test environmental conditions using the manufacturer's supplied information on the influence of atmospheric air pressure and temperature. This sound pressure level is used to establish the acoustical sensitivity of the measurement system. Within six months of each test series the output of the sound calibrator must be

determined by a method traceable to an organization recognized by the CAAC. Changes in output from the previous calibration must not exceed 0.2 dB.

182. Section A36.3.9.8

Sufficient sound pressure level calibrations must be made during each test day to ensure that the acoustical sensitivity of the measurement system is known at the prevailing environmental conditions corresponding with each test series. The difference between the acoustical sensitivity levels recorded immediately before and immediately after each test series on each day may not exceed 0.5 dB. The 0.5 dB limit applies after any atmospheric pressure corrections have been determined for the calibrator output level. The arithmetic mean of the before and after measurements must be used to represent the acoustical sensitivity level of the measurement system for that test series. The calibration corrections must be reported to the CAAC and applied to the measured one-third octave band sound pressure levels determined from the output of the analyzer.

183. Section A36.3.9.9

Each recording medium, such as a reel, cartridge, cassette, or diskette, must carry a sound pressure level calibration of at least 10 seconds duration at its beginning and end.

184. Section A36.3.9.10

The free-field insertion loss of the windscreen for each one-third octave nominal midband frequency from 50 Hz to 10 kHz inclusive must be determined with sinusoidal sound signals at the incidence angles determined to be applicable for correction of directional response effects per section A36.3.9.3. The interval between angles tested must not exceed 30 degrees. For a windscreen that is undamaged and uncontaminated, the insertion loss may be taken from manufacturer's data. Alternatively, within six months of each test series the insertion loss of the windscreen may be determined by a method traceable to an organization recognized by the CAAC. Changes in the insertion loss from the previous calibration at each one-third-octave frequency band must not exceed 0.4 dB. The correction for the free-field insertion loss of the windscreen must be reported to the CAAC and applied to the measured one-third octave sound pressure levels determined from the output of the

analyzer.

a. Explanation

Sections A36.3.9.1 through A36.3.9.10 specify the performance requirements for calibration systems and the procedures for calibration of the noise measurement system used for airplane noise certification.

b. Supplemental Information

(1) Pink Noise: Pink noise contains equal energy in each octave band or fractional octave band (e.g., the octave from 100 Hz to 200 Hz contains the same amount of energy as the octave from 1 kHz to 2 kHz, although for the lower-frequency octave, it is distributed over a frequency range 10 times narrower).

(2) Note on Pink Noise Usage: Because of the dynamic nature of the pink noise signal, longer samples produce statistically better measurements. At a minimum, recorded pink noise signals must have durations of 30 seconds.

(3) Acoustic Calibrator Output Adjustments: Acoustic calibrator outputs may require adjustment for ambient conditions (such as temperature and atmospheric pressure), coupler volume, etc. Section A36.3.9.8 requires that all such adjustments be applied in the data processing stage rather than by using an adjusted calibration value in the analyzer. In this way, a traceable record of the adjustments can be maintained.

(4) Calibration Traceability: All performance calibration analyses of calibration equipment must be traceable to the organization determined by the CAAC.

c. Procedures

(1) Measurement System Field Calibration (All components of the measurement system except microphones): All components of the measurement system, except microphones, must be tested while deployed in the field using pink noise at a level within 5 dB of the calibration level (as specified in A36.3.9.5). The signal must be recorded for a duration of at least 30 seconds so that one-third octave-band system frequency response adjustments can be determined and applied during analysis. The pink noise generator must be calibrated within 6 months of the measurement, and is acceptable for certification use only if its output in each one-third octave band does not change by more than 0.2 dB between calibrations.

(2) Field Acoustical Calibrations: At the start and end of each measurement day, at the beginning of each physical recording (each tape reel, cartridge, cassette, disk, etc.), and at the end of the last physical recording, an acoustic calibration signal of known amplitude and frequency must be fed through the entire measurement system (including microphone) as deployed in the field, and recorded. All components of the system (excluding the windscreen) must be in place at this time, including cables, attenuators, gain and signalconditioning amplifiers, filters (including preemphasis) and power supplies. During calibration, attenuators and gain stages must be set to prevent overload, and to maintain the calibration signal level on the reference level range within the limits specified in section A36.3.6.6. If any switchable filters that could affect the calibration signal are utilized during measurements, then calibrations must be performed both with and without these filters enabled. Components of the electrical system must not be added, removed, or replaced without re-calibrating the entire system immediately before and after each change.

The 0.5 dB limit stated in section A36.3.9.8 requires that sufficient determinations be made of the entire system's acoustical sensitivity during each measurement day to ensure that the response of the equipment is known for each test. The equipment shall be considered satisfactory if (after the required calibrator corrections are applied) the recorded variation over the period immediately before and immediately after each test series, within a given day, is not more than 0.5 dB.

(3) Measurement Program Equipment Calibration Schedules:

(i) Microphones and preamplifiers (also windscreens, if included in free-field calibration): Pressure-response or free-field calibration within the 90 days of the measurement program.

(ii) One-Third-Octave-Band Analyzers: Within 6 months of the measurement program.

(iii) Recorders, Amplifiers, Filters, etc.: Within 6 months of the measurement program.

(iv) Calibration Equipment: Within 6 months of the measurement program, traceable to the organization determined by the CAAC.

(4) Applications of Adjustments for Incidence: When using microphones whose frequency response is nearly flat at grazing incidence, and when the angles of incidence of sound emitted from the aircraft are within ± 30° of

grazing incidence, a single set of data adjustments for free-field response (and windscreen insertion loss), based on grazing incidence, is considered sufficient to account for incidence effects. When it is impractical to orient the microphone properly to maintain grazing incidence, provided that a continuous record of TPSI is available, free-field (and windscreen insertion-loss) incidence data adjustments can be applied to the noise data on a spectral-record-by-spectral-record basis. These adjustments are obtained by calculating the angle of incidence for each record, using the point of time which characterizes the 2-second averaging period (per section A36.3.7.6), and determining the airplane's emission coordinates (and angle of incidence) for the sound measured at that time.

(5) Determination of Windscreen Data Adjustments: The physical condition of a windscreen can significantly affect its performance, and manufacturer-provided windscreen data adjustments for insertion loss are only valid for new, or clean, dry windscreens. For these adjustments, a single set of values based upon wind screen insertion loss tests at grazing incidence may be used when the angles of incidence of sound emitted from an aircraft are within + 30 degrees of grazing incidence. For other cases, the windscreen insertion loss adjustments must be determined and applied on the basis of intervals between angles tested not exceeding 30 degrees.

When the windscreen data adjustments provided by the manufacturer are presented in the form of curves, care must be taken to include the insertion loss throughout each one-third-octave band, rather than just at the nominal midband frequency. Windscreen insertion loss can vary substantially within the frequency range of a single band and must be averaged or faired to more accurately correct one-third-octave-band data for the presence of the windscreen. Windscreen data adjustments may also be obtained by free-field calibration in an anechoic chamber.

185. Section A36.3.10 Adjustments for ambient noise

186. Section A36.3.10.1

Ambient noise, including both an acoustical background and electrical noise of the measurement system, must be recorded for at least 10 seconds at the measurement points with the system gain set at the levels used for the aircraft noise measurements. Ambient noise must be representative of the acoustical background that exists during the flyover test run. The recorded

aircraft noise data is acceptable only if the ambient noise levels, when analyzed in the same way, and quoted in PNL (see A36.4.1.3 (a)), are at least 20 dB below the maximum PNL of the aircraft.

a. Explanation

This section specifies procedures for ambient noise measurements, and the acceptability limit for comparison of aircraft PNL against ambient PNL.

b. Supplemental Information

(1) Ambient Noise: The term "ambient noise" as specified in section A36.3.10.1 includes the acoustical background noise present at a microphone site, generated by sources other than the subject aircraft and the electrical background noise from the measurement system. This specification ensures that any signals that can affect the measured levels of aircraft noise can be properly quantified.

(2) Background Noise: The term "background noise" as used in Appendix 3 of the appended TM and Appendix 3 of this AC describes all noise from sources other than the subject aircraft which can influence or obscure the noise levels being measured including ambient noise, and analytical noise from the measurement system (e.g., the baseline of an analysis window or the amplitude non-linearity characteristics of measurement system components). The elements of background noise can be characterized as one of two types: Pre-detection noise, which contributes energy to the signal level being measured; and Post-detection noise, which does not contribute energy to the measured signal level. Appendix 3 of this AC provides detailed information on the characteristics of background noise, and detailed procedures for adjusting measured aircraft noise levels for the effects of ambient and other types of background noise.

c. Procedures

(1) Measurement System Noise: Since measurement system noise can add energy to measured aircraft noise levels, the ambient noise measurement described in section A36.3.10.1 must be made with all gain stages and attenuators set as they would be used during the aircraft noise certification measurements. If it is expected that multiple settings will be required during the measurements, ambient noise data must be collected at each of these settings. Whenever possible, ambient noise recordings should be made for at least 30 seconds each, and care should be taken to ensure that the ambient noise is truly representative of that present during the aircraft noise certification tests.

(2) Mean Ambient Noise Assessments: At least 10 seconds, but preferably 30 seconds, of ambient noise data must be time-averaged to determine the mean level for each one-third octave band. The PNL value for this averaged spectrum must then be calculated using the procedures defined in section A36.4.2. The aircraft noise level data must also be analyzed, and PNL values calculated for each spectral record. The maximum aircraft PNL value must be at least 20 dB above the PNL of the averaged ambient noise spectrum for the data to be considered acceptable.

187. Section A36.3.10.2

Aircraft sound pressure levels within the 10 dB-down points (see A36.4.5.1) must exceed the mean ambient noise levels determined in section A36.3.10.1 by at least 3 dB in each one-third octave band, or must be adjusted using a method approved by the CAAC; one method is described in the current advisory circular for this part.

a. Explanation

This section quantifies the amount by which aircraft sound pressure levels must exceed the mean ambient noise levels for noise certification testing, and specifies the requirement for data adjustment in cases where this exceedance amount is not met.

b. Supplemental Information

(1) Background Noise Adjustments: Adjustments must be applied for the effects of ambient and other types of background noise on measured aircraft sound pressure levels. Determination of masking must be accomplished before any frequency-dependent adjustments are applied (such as for system frequency response or microphone free-field response). Appendix 3 of the appended ICAO TM presents a background noise adjustment method that represents the international recommended practice. FAA has developed procedures contained in Appendix 3 of this AC to provide the applicant with a more definitive methodology for accounting for the effects of background noise, including some procedural elements not contained in the TM Appendix 3. The Technical Issues Task Group of Working Group 1 of the ICAO Committee on Aviation Environmental Protection is considering possible revision to the ICAO TM Appendix 3 background noise adjustment method based upon review of the procedures contained in Appendix 3 of this AC.

c. Procedures

None

188. Section A36.4 Calculation of Effective Perceived Noise Level From Measured Data

189. Section A36.4.1 General

190. Section A36.4.1.1

The basic element for noise certification criteria is the noise evaluation measure known as effective perceived noise level, EPNL, in units of EPNdB, which is a single number evaluator of the subjective effects of airplane noise on human beings. EPNL consists of instantaneous perceived noise level, PNL, corrected for spectral irregularities, and for duration. The spectral irregularity correction, called "tone correction factor", is made at each time increment for only the maximum tone.

191. Section A36.4.1.2

A36.4.1.2 Three basic physical properties of sound pressure must be measured: level, frequency distribution, and time variation. To determine EPNL, the instantaneous sound pressure level in each of the 24 one-third octave bands is required for each 0.5 second increment of time during the airplane noise measurement.

192. Section A36.4.1.3

The calculation procedure that uses physical measurements of noise to derive the EPNL evaluation measure of subjective response consists of the following five steps:

(a) The 24 one-third octave bands of sound pressure level are converted to perceived noisiness (noy) using the method described in section A36.4.2.1 (a). The noy values are combined and then converted to instantaneous perceived noise levels, PNL(k).

(b) A tone correction factor C(k) is calculated for each spectrum 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 tone-corrected perceived noise levels PNLT(k), at each one-half second increment:

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

The instantaneous values of tone-corrected perceived noise level are derived and the maximum value, PNLTM, is determined.

(d) A duration correction factor, D, is computed by integration under the curve of tone-corrected perceived noise level versus time.

(e) Effective perceived noise level, EPNL, is determined by the algebraic sum of the maximum tone- corrected perceived noise level and the duration correction factor:

$$EPNL = PNLTM + D$$

a. Explanation

This section specifies that the noise rating for an individual airplane event for purposes of noise certification is Effective Perceived Noise Level (EPNL in units of EPNdB). It is based on the results of extensive psycho-acoustical research conducted primarily in the 1950's and early 1960's concerning the subjective effects of airplane noise on human beings. EPNL is a single number measure of the noise of an individual airplane flyover that approximates laboratory annoyance responses. It is derived from calculations of perceived noise level (PNL, in units of PNdB), adjusted for the presence of audible pure tones or discrete frequencies (PNLT, in units of TPNdB), and for duration of the airplane flyover. The PNL metric accounts for variations in hearing sensitivity as a function of frequency. The PNLT metric additionally accounts for the effects of tones, which are often present in complex sounds such as airplane noise. The EPNL metric further accounts for the effect of the duration of the noise. The EPNL computation process effectively yields a time integrated annoyance level.

b. Supplemental Information

None

c. Procedures

None

193. Section A36.4.2 Perceived noise level.

194. Section A36.4.2.1

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

(a) Step 1: For each one-third octave band from 50 through 10,000 Hz, convert SPL(i,k) to perceived noisiness n(i,k), by using the mathematical formulation of the noy table given in section A36.4.7.

(b) Step 2: Combine the perceived noisiness values, n(i,k), determined in step 1 by using 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.

(c) Step 3: Convert the total perceived noisiness, N(k), determined in Step 2 into perceived noise level, PNL(k), using the following formula:

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

Note: PNL(k) is plotted in the current advisory circular for this part.

a. Explanation

This section specifies the method(s) used to calculate perceived noise level (PNL, in units of PNdB) for each one-third-octave-band spectral record, i.e., each one-half second spectrum. A plot of PNL(k) versus total noisiness (N) is presented in Figure 4-1 of Appendix 4 of the appended TM.

b. Supplemental Information

(1) "Instantaneous" Sound Pressure Levels: For the purposes of this procedure, "instantaneous" Sound Pressure levels are considered to be one-third-octave-band sound pressure levels for each half-second record obtained using a continuous exponential averaging process as described in section A36.3.7.4.

c. Procedures

None

195. Section A36.4.3 Correction for spectral irregularities

196. Section A36.4.3.1

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

a. Explanation

This section specifies a 10-step procedure for identifying the tonal content of each one-third-octaveband spectrum and for determining correction factors for converting PNL values to values designated as PNLT.

b. Supplemental Information

None

c. Procedures

(1) Data Precision for Tone Correction Computation: Prior to Step 1, all one-third-octave-band sound pressure levels should be temporarily rounded to 0.1 dB resolution. The tone-correction procedure presented here includes several steps that utilize decibel level criteria to characterize the significance of tonal content. These criteria can become artificially sensitive to small variations in level if resolution finer than 0.1 dB is used in the computations.

(a) Step 1: After applying the corrections specified under section A36.3.9, start with the 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:

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

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

•

•

$$s(i,k) = SPL(i,k) - SPL(i-1,k)$$

•

•

$$s(24,k) = SPL(24,k) - SPL(23,k)$$

(b) 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:

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

(c) Step 3:

(1) If the encircled value of the slope s(i,k) is positive and algebraically greater than the slope s(i−1,k) encircle SPL(i,k).

(2) If the encircled value of the slope s(i,k) is zero or negative and the slope s(i−1,k) is positive, encircle SPL(i−1,k).

(3) For all other cases, no sound pressure level value is to be encircled.

a. Explanation

Steps 1-3 specify the method used to identify significant tones in spectral data.

b. Supplemental Information

None

c. Procedures

None

(d) Step 4: Compute new adjusted sound pressure levels SPL′ (i,k) as follows:

(1) For non-encircled sound pressure levels, set the new sound pressure levels equal to the original sound pressure levels, SPL′ (i,k) = SPL(i,k).

(2) For encircled sound pressure levels in bands 1 through 23 inclusive, set the new sound pressure level equal to the arithmetic average of the preceding and following sound pressure levels as shown below:

$$SPL'(i,k) = [SPL(i-1,k) + SPL(i+1,k)]$$

(3) If the sound pressure level in the highest frequency band (i=24) is encircled, set the new sound pressure level in that band equal to:

$$SPL'(24,k) = SPL(23,k) + s(23,k)$$

(e) Step 5: Recompute new slope s′ (i,k), including one for an imaginary 25th band, as follows:

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

$$s'(4,k) = SPL'(4,k) - SPL'(3,k)$$

•

•

$$s'(i,k) = SPL'(i,k) - SPL'(i-1,k)$$

•

•

$$s'(24,k) = SPL'(24,k) - SPL'(23,k)$$

$$s'(25,k) = s'(24,k)$$

(f) Step 6: For i, from 3 through 23, compute the arithmetic average of the three adjacent slopes as follows:

$$(i,k) = \quad [s'(i,k) + s'(i+1,k) + s'(i+2,k)]$$

(g) Step 7: Compute final one-third octave-band sound pressure levels, SPL″ (i,k), by beginning with band number 3 and proceeding to band number 24 as follows:

$$SPL''(3,k) = SPL(3,k)$$

$$SPL''(4,k) = SPL''(3,k) + \quad (3,k)$$

•

•

$$SPL''(i,k) = SPL''(i-1,k) + \quad (i-1,k)$$

•

•

$$SPL''(24,k) = SPL''(23,k) + \quad (23,k)$$

a. Explanation

Steps 4 through 7 specify methods to smooth one-third-octave-band spectra to obtain pseudobroadband levels that would have been present in the absence of tones.

b. Supplemental Information

None

c. Procedures

1. Data Adjustments for Background Noise: When the procedure presented in Appendix 3 of this Advisory Circular is used for correction for the effects of background noise, Steps 4 and 5 of this tone-correction procedure should be modified as follows:

Step 4(3) - The "Last Good Band" (LGB) should be used in place of the highest-frequency band (i=24).

Step 5 - A new slope, s'(25,k), should be calculated for the band beyond LGB as described for an imaginary 25-th band. This slope should be used in place of the slope derived from the actual level of the band beyond LGB. (See Supplementary Information under section A36.3.10.2(b)(1) for information on background noise correction procedures.)

(h) Setp 8: Calculate the differences, F(i,k), between the original sound pressure level and the final background sound pressure level as follows:

$$F(i,k) = SPL(i,k) - SPL''(i,k)$$

and note only values equal to or greater than 1.5.

a. Explanation

Step 8 specifies a requirement to compare the differences between a derived sound pressure level and the original sound pressure level.

b. Supplemental Information

None

c. Procedures

None

(i) Step 9: For each of the relevant one-third octave bands (3 through 24), determine tone correction factors from the sound pressure level differences F(i,k) and Table A36-2.

a. Explanation

Step 9 specifies a method of determining a tone correction factor for each tone.

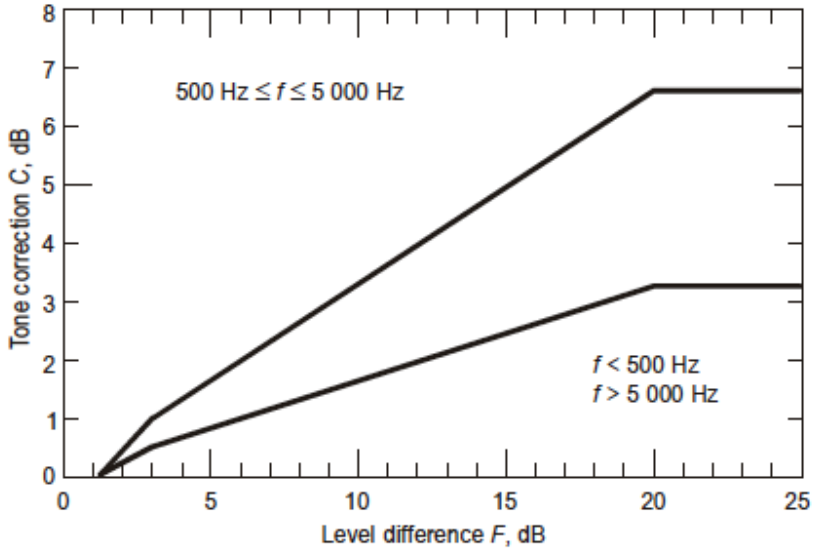
b. Supplemental Information

None

c. Procedures

None

Table A36-2. Tone correction factors



Frequency f, Hz	Level difference F, dB	Tone correction C, dB
$50 \leq f < 500$	$1½^* \leq F < 3$	$F/3 - ½$
	$3 \leq F < 20$	$F/6$
	$20 \leq F$	3⅓
$500 \leq f \leq 5\,000$	$1½^* \leq F < 3$	$2F/3 - 1$
	$3 \leq F < 20$	$F/3$
	$20 \leq F$	6⅔
$5\,000 < f \leq 10\,000$	$1½^* \leq F < 3$	$F/3 - ½$
	$3 \leq F < 20$	$F/6$
	$20 \leq F$	3⅓

* See Step 8

(j) 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 current advisory circular for this part). Tone- corrected perceived noise levels PNLT(k) must 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 airplane 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 background 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 may be approved.

a. Explanation

Step 10 specifies the method for identifying the largest tone correction factor associated with the spectrum and then adding this correction to PNL(k) to obtain PNLT(k). An example of tone correction calculation for a turbofan engine is presented in Table 4-2 of the appended TM. The additional text following Step 10 describes an allowance to eliminate tone-corrections that are attributable to sources or causes other than the test aircraft, including pseudotones.

Note: The term "background" in this case, refers the broadband noise level that would be present in the one-third octave band in the absence of the tone, and not to the ambient noise described in section A36.3.10.

b. Supplemental Information

None

c. Procedures

(1) Data Precision (after Calculation of Tone Correction Factor): At this point, the original sound pressure level resolution of .01 dB must be restored. Although the required precision of reported EPNL is 0.1 dB, all other intermediate calculations external to the tone correction process must maintain a precision of at least 0.01 dB.

(2) Identification of Pseudotones: Appendix 2 of the appended ICAO TM presents guidance material on methods for identifying pseudo-tones. Note that the use of ground plane or 10-meter microphones is supplemental to the required 4-foot (1.2-meter) microphones, and is allowed only for identification of

frequency bands within which pseudotones occur, not for the determination of aircraft noise certification levels.

(3) Tone Correction Factor Adjustment: When tone-correction factors result from false or fictitious tones, recalculation is allowed using revised sound pressure level values (based on narrow-band analysis) of the smoothed spectral levels obtained in Step 7. Once the levels have been revised, the tone-correction factor must be recomputed for the revised one-third octave band spectrum. This recomputed maximum tone-correction factor must be applied, even if it occurs at or near the band associated with an artificial tone, and FAA approval must be obtained for the methodology used.

197. Section A36.4.3.2

The tone correction procedure will underestimate EPNL if an important tone is of a frequency such that it is recorded in two adjacent one-third octave bands. An applicant must demonstrate that either:

(a) No important tones are recorded in two adjacent one-third octave bands; or

(b) That if an important tone has occurred, 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.

a. Explanation

None

b. Supplemental Information

(1) Band sharing is discussed under section A36.4.4.2.

c. Procedures

None

198. Section A36.4.4 Maximum tone-corrected perceived noise level

199. Section A36.4.4.1

The maximum tone-corrected perceived noise level, PNLTM, must be the maximum calculated value of the tone-corrected perceived noise level PNLT(k). It must be calculated using the procedure of section A36.4.3. To

obtain a satisfactory noise time history, measurements must be made at 0.5 second time intervals.

Note 1: Figure A36–2 is an example of a flyover noise time history where the maximum value is clearly indicated.

Note 2: In the absence of a tone correction factor, PNLTM would equal PNLM.

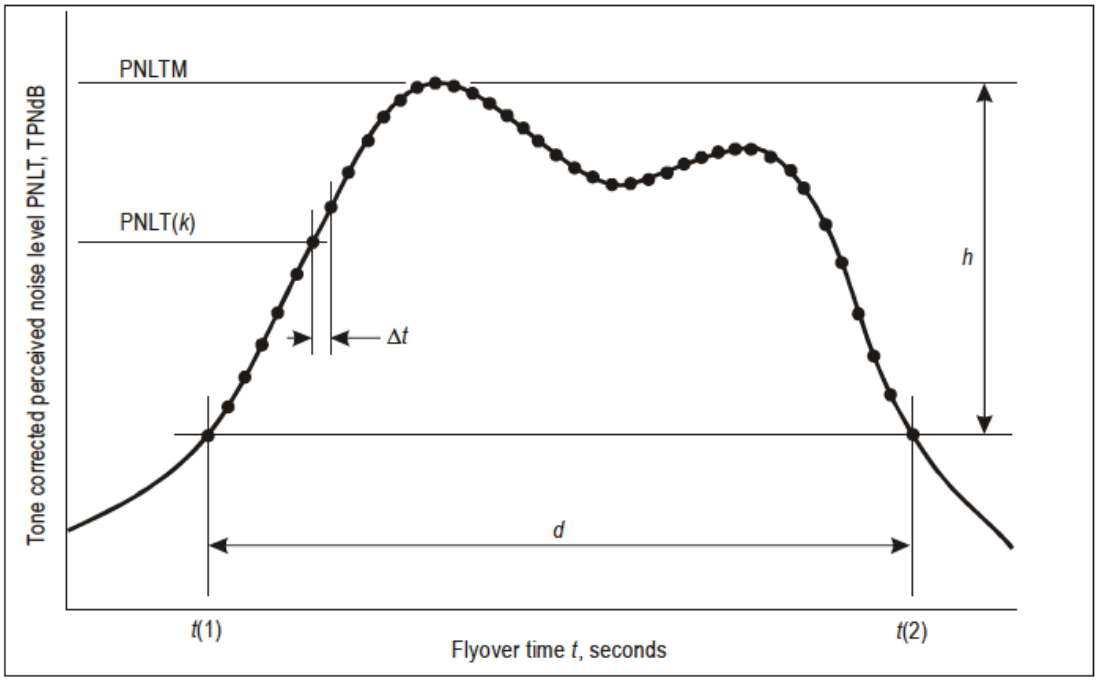


Figure A36-2. Example of perceived noise level corrected for tones as a function of aeroplane flyover time

200. Section A36.4.4.2

After the value of PNLTM is obtained, the frequency band for the largest tone correction factor is identified for the two preceding and two succeeding 500 ms data samples. This is performed in order to identity the possibility of tone suppression at PNLTM by one-third octave band sharing of that tone. If the value of the tone correction factor C(k) for PNLTM is less than the average value of C(k) for the five consecutive time intervals, the average value of C(k) must be used to compute a new value for PNLTM.

a. Explanation

This section specifies the method of accounting for the effects of the suppression of tones occurring at or near the band edges of one-third-octave-band filters when determining a tone correction factor at the

time of PNLTM.

b. Supplemental Information

(1) Band Sharing Adjustment Concept: The one-third-octave-band filtering process specified for analysis of airplane noise certification data may allow the tone-correction procedure presented in section A36.4.3 to under-predict a tone correction factor when the frequency of a tone is located at or near the edge of one or more one-third-octave bands. To account for this phenomenon, a band sharing adjustment is computed that takes advantage of the fact that, as a result of the Doppler Effect, a tone that is suppressed at PNLTM will probably appear normally in the spectra that occur before or after PNLTM. By averaging the tone correction factors calculated for the spectra within a 2-second period around PNLTM, the tone correction factor that would have occurred at PNLTM if it were not suppressed can be reasonably estimated.

c. Procedures

(1) Computation of Band Sharing Adjustment: Although part 36 refers to identification of the frequency bands in which maximum tone-corrections occur for the records near PNLTM, the presence or absence of band-sharing cannot be established merely by observing these frequencies. Even though the maximum tone that occurs in a one-third-octave band spectrum may not be related to the band of maximum tone-correction in the PNLTM spectrum, a related tone may still be present. Therefore, the average of the tone-corrections of all spectra within 1-second (five one-half second data records) of PNLTM must be used regardless of the bands in which maximum tones are found. If the band sharing adjustment is believed to result from effects other than band sharing, the applicant must demonstrate its absence for each event.

(2) Adjustment of PNLTM for Band Sharing: The band sharing adjustment must be computed before the determination of the 10 dB-down period and must be included in the reported PNLTM and EPNL values for the test condition data.

(3) Application of Band Sharing Adjustment for Simplified Procedure: When the simplified procedure is used to adjust data to reference conditions, the bandsharing adjustment, must be applied to the $PNLT_r$ at time of PNLTM before Δ_1 and EPNLr is calculated.

(4) Application of Band Sharing Adjustment for Integrated Procedure: When the integrated procedure is used to adjust data to reference conditions, a new band sharing adjustment must be calculated from the five data records for

the one-third-octave-band spectra (adjusted to reference conditions) encompassing the $PNLT_r$ at time of PNLTM (this includes two data records prior to PNLTr at time of PNLTM, the $PNLT_r$ at time of PNLTM record, and two data records after $PNLT_r$ at time of PNLTM).

201. Section A36.4.5 Duration correction

202. Section A36.4.5.1

The duration correction factor D determined by the integration technique is defined by the expression:

$$D = 10\log\left[\left(\frac{1}{T}\right)\int_{t(1)}^{t(2)} \text{anti}\log\frac{\text{PNLT}}{10}dt\right] - \text{PNLTM}$$

where T is a normalizing time constant, PNLTM is the maximum value of PNLT, t(1) is the first point of time after which PNLT becomes greater than PNLTM−10, and t(2) is the point of time after which PNLT remains constantly less than PNLTM−10.

203. Section A36.4.5.2

Since PNLT is calculated from measured values of sound pressure level (SPL), there is no obvious equation for PNLT as a function of time. Consequently, the equation is to be rewritten with a summation sign instead of an integral sign as follows:

$$D = 10\log\left[\left(\frac{1}{T}\right)\sum_{k=0}^{d/\Delta t}\Delta t\cdot\text{anti}\log\frac{\text{PNLT}(k)}{10}\right] - \text{PNLTM}$$

where Δt is the length of the equal increments of time for which PNLT(k) is calculated and d is the time interval to the nearest 0.5 seconds during which PNLT(k) remains greater or equal to PNLTM−10.

204. Section A36.4.5.3

To obtain a satisfactory history of the perceived noise level use one of the following:

(a) Half-Second time intervals for Δt; or

(b) A shorter time interval with approved limits and constants.

205. Section A36.4.5.4

The following values for T and Δt must be used in calculating D in the equation given in section A36.4.5.2:

T = 10 s, and

Δt = 0.5s (or the approved sampling time interval).

Using these values, the equation for D becomes:

$$D = 10\log\left[\sum_{k=0}^{2d}\text{anti}\log\frac{\text{PNLT}(k)}{10}\right] - \text{PNLTM} - 13$$

where d is the duration time defined by the points corresponding to the values PNLTM−10.

a. Explanation

None

b. Supplemental Information

(1) EPNL Equations: The equation for the duration correction, D, as shown in A36.4.5.4, is valid only for records of one-half second in length. The constant value 13 is used to normalize the one-half second values to the 10-second standard duration (10*log10 (10 seconds of ½ -second data records = 20 records) =13.01).

c. Procedures

None

206. Section A36.4.5.5

If in using the procedures given in section A36.4.5.2, the limits of PNLTM−10 fall between the calculated PNLT(k) values (the usual case), the PNLT(k) values defining the limits of the duration interval must be chosen from the PNLT(k) values closest to PNLTM−10. For those cases with more than one peak value of PNLT(k), the applicable limits must be chosen to yield the largest possible value for the duration time.

a. Explanation

This section specifies a requirement to calculate a duration correction, D, which is determined by means of integrating (summing) the PNLT values within

10 dB of PNLTM.

b. Supplemental Information

None

c. Procedures

(1) Identification of the First and Last Records Within the 10 dB-Down Period: When identifying the records that define the limits of the 10 dB-down period, those records having PNLT values closest to the actual value of PNLTM-10 dB must be used. As a result, the PNLT values for the PNLTM-10 dB points may not always be greater than or equal to PNLTM-10 dB.

(2) Calculation of the Duration Correction, D: When calculating the value of D, the full PNLT value and duration of each record within the 10 dB-down period must be included. Interpolation of discrete PNLT values to the exact point of PNLTM-10 dB is not allowed.

(3) Recorded Data: If recorded data do not encompass the entire 10 dB-down period, an EPNL cannot be calculated from those data, and the event must not be used for aircraft noise certification purposes.

207. Section A36.4.6 Effective perceived noise level

208. Section A36.4.6

The total subjective effect of an airplane noise event, designated effective perceived noise level, EPNL, is equal to the algebraic sum of the maximum value of the tone-corrected perceived noise level, PNLTM, and the duration correction D. That is:

$$EPNL = PNLTM + D$$

where PNLTM and D are calculated using the procedures given in sections A36.4.2, A36.4.3, A36.4.4. and A36.4.5.

209. Section A36.4.7 Mathematical formulation of noy tables

210. Section A36.4.7.1

The relationship between sound pressure level (SPL) and the logarithm of perceived noisiness is illustrated in Figure A36-3 and Table A36-3.

211. Section A36.4.7.2

The bases 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).

212. Section A36.4.7.3 Calculate noy values using the following equations:

(a) SPL ⩾SPL(a)

n = antilog{M(c)[SPL − SPL(c)]}

(b) SPL(b) ⩽SPL<SPL(a)

n = antilog{M(b)[SPL − SPL(b)]}

(c) SPL(e) ⩽SPL<SPL(b)

n = 0.3antilog{M(e)[SPL − SPL(e)]}

(d) SPL(d) ⩽SPL<SPL(e)

n = 0.1antilog{M(d)[SPL − SPL(d)]}

213. Section A36.4.7.4

Table A36-3 lists the values of the constants necessary to calculate perceived noisiness as a function of sound pressure level.

a. Explanation

This section specifies a requirement for using table A36-3 constants to calculate perceived noy values related to sound-pressure-level values.

b. Supplemental Information

None

c. Procedures

None

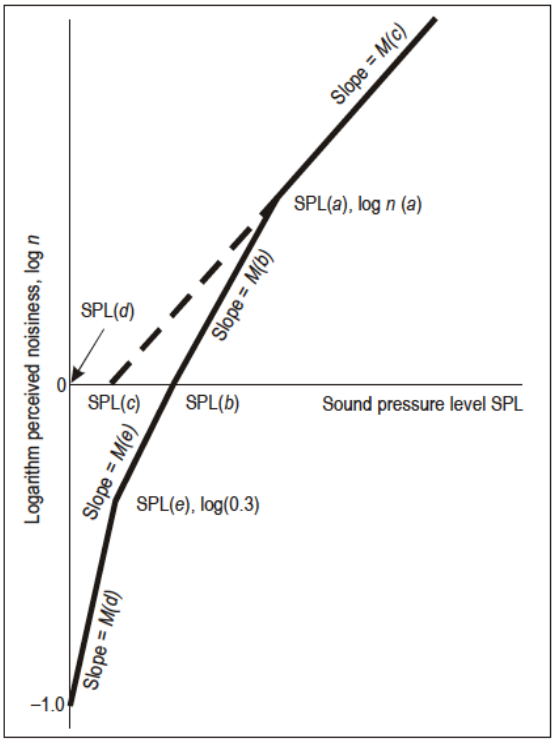


Figure A36-3. Perceived noisiness as a function of sound pressure level

Table A36-3. Tone correction factors

BAND (*i*)	*f* Hz	SPL (*a*)	SPL (*b*)	SPL (*c*)	SPL (*d*)	SPL (*e*)	*M*(*b*)	*M*(*c*)	*M*(*d*)	*M*(*e*)
1	50	91.0	64	52	49	55	0.043478	0.030103	0.079520	0.058098
2	63	85.9	60	51	44	51	0.040570		0.068160	”
3	80	87.3	56	49	39	46	0.036831		”	0.052288
4	100	79.0	53	47	34	42	”		0.059640	0.047534
5	125	79.8	51	46	30	39	0.035336		0.053013	0.043573
6	160	76.0	48	45	27	36	0.033333			”
7	200	74.0	46	43	24	33	”			0.040221
8	250	74.9	44	42	21	30	0.032051			0.037349
9	315	94.6	42	41	18	27	0.030675	0.030103		0.034859
10	400	∞	40	40	16	25	0.030103			
11	500		40	40	16	25				
12	630		40	40	16	25				
13	800		40	40	16	25				
14	1 000		40	40	16	25			0.053013	
15	1 250		38	38	15	23	0.030103		0.059640	0.034859
16	1 600		34	34	12	21	0.029960		0.053013	0.040221
17	2 000		32	32	9	18			”	0.037349
18	2 500		30	30	5	15			0.047712	0.034859
19	3 150		29	29	4	14			”	
20	4 000		29	29	5	14			0.053013	
21	5 000		30	30	6	15			”	0.034859
22	6 300	∞	31	31	10	17	0.029960	0.029960	0.068160	0.037349
23	8 000	44.3	37	34	17	23	0.042285		0.079520	”
24	10 000	50.7	41	37	21	29	”	”	0.059640	0.043573

NOT APPLICABLE

214. Section A36.5. Reporting of Data to the CAAC

215. Section A36.5.1 General

216. Section A36.5.1.1

Data representing physical measurements and data used to make corrections to physical measurements must be recorded in an approved permanent form and appended to the record.

217. Section A36.5.1.2

All corrections must be reported to and approved by the CAAC, including corrections to measurements for equipment response deviations.

218. Section A36.5.1.3

Applicants may be required to submit estimates of the individual errors inherent in each of the operations employed in obtaining the final data.

a. Explanation

None.

b. Supplemental Information

(1) Compliance Records: For compliance with section A36.5.1.1 through A36.5.1.3, all data measured during noise certification testing, including all time histories of physical measurements, noise recordings, instrument calibrations, etc., are to be recorded in permanent form and made available to the CAAC for review, inspection, and approval. A common procedure is for the applicant to submit representative samples of test data for each noise measurement point and adjustments to measured data to permit the CAAC to determine compliance with the regulation. The applicant may either: 1.) submit the complete test records along with the required corrections, or 2.) when approved by the CAAC, the applicant may instead submit samples of test data along with the required data adjustments.

c. Procedures

(1) Test Records: All test records are to be submitted to the CAAC for compliance review and approval. Adjustments to the measured data are also to be submitted to the CAAC for review and approval. The CAAC may require an

applicant to submit records showing estimates of the magnitude of potential errors at each step in the measurement, analysis, and adjustment of data. Specific data-reporting requirements are identified in section A36.5.2.

219. Section A36.5.2 Data reporting

An applicant is required to submit a noise certification compliance report that includes the following.

a. Explanation

None.

b. Supplemental Information

(See section 36.1501(a))

c. Procedures

None

220. Section A36.5.2.1

The applicant must present measured and corrected sound pressure levels in one-third octave band levels that are obtained with equipment conforming to the standards described in section A36.3 of this appendix.

221. Section A36.5.2.2

The applicant must report the make and model of equipment used for measurement and analysis of all acoustic performance and meteorological data.

222. Section A36.5.2.3

The applicant must report the following atmospheric environmental data, as measured immediately before, after, or during each test at the observation points prescribed in section A36.2 of this appendix.

(a) Air temperature and relative humidity;

(b) Maximum, minimum and average wind velocities; and

(c) Atmospheric pressure.

223. Section A36.5.2.4

The applicant must report conditions of local topography, ground cover, and events that might interfere with sound recordings.

224. Section A36.5.2.5

A36.5.2.5 The applicant must report the following:

(a) Type, model and serial numbers (if any) of airplane, engine(s), or propeller(s) (as applicable);

(b) Gross dimensions of airplane and location of engines;

(c) Airplane gross weight for each test run and center of gravity range for each series of test runs;

(d) Airplane configuration such as flap, airbrakes and landing gear positions for each test run;

(e) Whether auxiliary power units (APU), when fitted, are operating for each test run;

(f) Status of pneumatic engine bleeds and engine power take-offs for each test run;

(g) Indicated airspeed in kilometers per hour or knots for each test run;

(h) Engine performance data:

(1) For jet airplanes: engine performance in terms of net thrust, engine pressure ratios, jet exhaust temperatures and fan or compressor shaft rotational speeds as determined from airplane instruments and manufacturer's data for each test run;

(2) For propeller-driven airplanes: engine performance in terms of brake horsepower and residual thrust; or equivalent shaft horsepower; or engine torque and propeller rotational speed; as determined from airplane instruments and manufacturer's data for each test run;

(i) Airplane flight path and ground speed during each test run; and

(j) The applicant must report whether the airplane has any modifications or non-standard equipment likely to affect the noise characteristics of the airplane. The CAAC must approve any such modifications or non-standard equipment.

a. Explanation

This section specifies the noise certification data-reporting requirements.

b. Supplemental Information

(1) Applicant's Reporting Requirements: Following are items that the applicant also must report in meeting the requirements of sections A36.5.2.1 through A36.5.2.5:

(i) Test conditions throughout the 10 dB-down period, including test airspeed, engine performance parameters, and airplane flight path position.

(ii) Recorder sampling rates.

(iii) Airplane and engine performance information, including airplane altitude and climb angle. Any other parameters that may affect the measurement or adjustment of acoustical, airplane, or engine performance data must also be recorded throughout the 10 dB-down period (e.g., SBV position, CG position).

c. Procedures

None

225. Section A36.5.3 Reporting of noise certification reference conditions.

226. Section A36.5.3.1

Airplane position and performance data and the noise measurements must be corrected to the noise certification reference conditions specified in the relevant sections of appendix B of this part. The applicant must report these conditions, including reference parameters, procedures and configurations.

a. Explanation

This section specifies a requirement to report reference conditions, parameters, procedures, and configurations used for noise certification testing.

b. Supplemental Information

(1) Reference Conditions: Reference conditions are specified under section B36.7.

(2) Equivalent Procedures: CAAC does not approve equivalent procedures for noise certification reference conditions.

(3) DER Information: Reference airplane performance is to be CAAC approved based on approved data. This may require that a flight analyst DER with appropriate authority for part 36 reference airplane performance submit completed report for review by the CAAC.

c. Procedures

None

227. Section A36.5.4 Validity of results.

228. Section A36.5.4.1

Three average reference EPNL values and their 90 percent confidence limits must 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 each measurement point (flyover, lateral, or approach). If more than one acoustic measurement system is used at any single measurement location, the resulting data for each test run must be averaged as a single measurement. The calculation must be performed by:

(a) Computing the arithmetic average for each flight phase using the values from each microphone point; and

(b) Computing the overall arithmetic average for each reference condition (flyover, lateral or approach) using the values in paragraph (a) of this section and the related 90 percent confidence limits.

229. Section A36.5.4.2

For each of the three certification measuring points, the minimum sample size is six. The sample size must be large enough to establish statistically for each of the three average noise certification levels a 90 percent confidence limit not exceeding ±1.5 EPNdB. No test result may be omitted from the averaging process unless approved by the CAAC.

Note: Permitted methods for calculating the 90 percent confidence interval are shown in the current advisory circular for this part.

a. Explanation

Appendix 1 of the appended TM describes methods for calculating 90 per cent confidence intervals

b. Supplemental Information

None

c. Procedures

None

230. Section A36.5.4.3

The average EPNL figures obtained by the process described in section A36.5.4.1 must be those by which the noise performance of the airplane is assessed against the noise certification criteria.

a. Explanation

This section specifies that average values of $EPNL_r$ (effective perceived noise level adjusted for reference conditions) for the flyover, lateral and approach noise measurement points are to be within a 90 percent confidence interval limit of ±1.5 dB. Both the mean EPNL levels and the associated confidence intervals are to be reported.

b. Supplemental Information

(1) Average $EPNL_r$ Levels: The average values of $EPNL_r$ are to be reported in a noise certification compliance document for flyover, lateral, and approach. The average value of $EPNL_r$ for n clustered data points, L_1, L_2, ……, L_n, is: $L_{mean} = (L_1 + L_2 + \cdots + L_n)(1/n)$. The average value of $EPNL_r$ from an NPD database is the noise level determined along the regression line through the adjusted data set at the appropriate thrust (power) and distance values, including any other additional adjustments necessary (e.g., adjustment to the airplane reference speed).

(2) 90 Percent Confidence Interval (Clustered Data): The test methods described in part 36 are conducted for a minimum of six repeated (e.g., at identical configuration, target thrust (power), and speed conditions) noise measurements for each of the three noise measurement points (flyover, lateral and approach). These repeated tests create three clusters of data for correction and evaluation. The 90 percent confidence interval validity evaluation of clusters of data can be easily determined. If n measurements of $EPNL_r$, (L_1, L_2, ……, L_n) are obtained under approximately the same conditions and it can be assumed that they constitute a random sample from a normal population, then the statistical 90 percent confidence interval value for each clustered group can

be derived.

(3) 90 Percent Confidence Interval (NPD Database): Noise-Power-Distance (NPD) database confidence intervals are determined by using a more general formulation than that used for a normal cluster of data points. The confidence interval is to be calculated about each data regression line, whether it is generated for flight test data, a combination of flight test and static test data, or analytical results.

(4) Single Test Values: When more than one noise measurement system is used at any one noise measurement point, the resulting noise level is to be the average of the measured noise levels for each noise measurement point. Some applicants prefer to provide multiple microphones at each noise measurement point. When multiple microphones are used during the noise testing, the average noise level is to be reported for each noise measurement.

(5) Valid Conditions: All valid noise measurements that are witnessed by an CAAC observer or an appropriate designee and determined to be valid are to be included in the confidence interval calculations even when they produce results that are outside the 90 percent confidence limit of ± 1.5 dB. The cause of erratic or possibly invalid noise data may include: testing under different temperature and humidity extremes, anomalous winds aloft, changes in measuring and recording equipment, changes in airplane hardware, background noise, shift in instrument calibrations, not testing in accordance with the approved test plan, etc. The CAAC observer is to make a determination, during the course of noise certification testing, as to the validity of all noise measurements. A noise measurement may not be excluded from the confidence interval calculations at a later date without CAAC approval. Noise measurements determined in the field to be invalid for any reason must be repeated.

c. Procedures

(1) Applicant's Responsibility: An applicant is responsible not only for the development of equivalent procedures but also for the development of procedures to quantify a 90 percent confidence interval determination when the approved equivalent procedures are used. The confidence interval procedures that are used in conjunction with approved equivalent procedures may be unique to each of the three measurement conditions (flyover, lateral and approach) and may be suitable for either simplified or integrated methods of evaluating the $EPNL_r$ levels.

(2) Methods for Calculating 90 percent Confidence Interval: Calculation methods for determining 90 percent confidence interval values for clustered and some other approved test results are presented in Appendix 1 of the appended ICAO TM. The TM provides confidence interval calculation methods for: clustered measurements, regression mean line, static test-derived NPD curves, and analytically derived NPD curves, and provides working examples (clustered, first-order regression curve, second-order regression curve, and the pooled data set).

(3) Reporting Requirements: $EPNL_r$ levels for each of the three noise measurement points (flyover, lateral, and approach) and the associated values of the 90% confidence intervals are to be reported to the CAAC in noise certification compliance documentation.

(4) Retest Requirements: The CAAC may require an applicant to retest or provide additional test data for any of the three noise measurement points (flyover, lateral or approach) when the reported results indicate:

(i) A required measurement is reported to be invalid, or

(ii) An insufficient number of measurements were conducted by the applicant to determine a suitable data sample, or

(iii) Data scatter indicates that the data are not from a normal population or trend (e.g., a discontinuity due to low power SBV operation), or

(iv) The 90 percent confidence interval for a noise measuring condition exceeds the allowable ±1.5 dB, or

(v) The test was not conducted in accordance with an approved noise certification compliance demonstration plan.

231. Section A36.6 Nomenclature: Symbols and Units

Symbol	Unit	Meaning
antilog		**Antilogarithm to the base 10.**
***C*(*k*)**	**dB**	***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.**
d	**s**	***Duration time.*** **The time interval between the limits of t (1) and t(2) to the nearest 0.5 second.**
D	**dB**	***Duration correction.*** **The factor to be added to PNLTM to account for the duration of the noise.**

EPNL	**EPNdB**	***Effective perceived noise level.*** **The value of PNL adjusted for both spectral irregularities and duration of the noise. (The unit EPNdB is used instead of the unit dB).**
$EPNL_r$	**EPNdB**	**Effective perceived noise level adjusted for reference conditions.**
***f*(*i*)**	**Hz**	***Frequency.*** **The geometrical mean frequency for the i-th one-third octave band.**
***F*(*i*,*k*)**	**dB**	***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. In this case, background sound pressure level means the broadband noise level that would be present in the one-third octave band in the absence of the tone.**
h	**dB**	***dB-down.*** **The value to be subtracted from PNLTM that defines the duration of the noise.**
H	**Percent**	***Relative humidity.*** **The ambient atmospheric relative humidity.**
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 10,000 Hz.**
k		***Time increment index.*** **The numerical indicator that denotes the number of equal time increments that have elapsed from a reference zero.**
log		**Logarithm to the base 10.**
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*(*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**	**The perceived noisiness at any instant of time that occurs in a specified frequency range.**
***n*(*i*,*k*)**	**noy**	**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**	**The perceived noise level at any instant of time. (The unit PNdB is used instead of the unit dB).**

PNL(*k*)	**PNdB**	**The perceived noise level calculated from the 24 values of SPL (i, k), at the 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 instead 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**	**The tone-corrected perceived noise level that occurs at the k-th increment of time. PNLT(k) is obtained by adjusting the value of PNL(k) 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).**
$PNLT_r$	**TPNdB**	**Tone-corrected perceived noise level adjusted for reference conditions.**
$s(i,k)$	**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.**
$\Delta s(i,k)$	**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.**
$\bar{s}\,(i,k)$	**dB**	**Average slope of sound pressure level.**
SPL	**dB re 20 µPa**	***Sound pressure level.*** **The sound pressure level that occurs in a specified frequency range at any instant of time.**
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*) SPL(*c*)	**dB re 20 µPa**	***Noy intercept.*** **The intercepts on the SPL-axis of the straight lines representing the variation of SPL with log n.**
SPL(*i*,*k*)	**dB re 20 µPa**	**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.**

$SPL(i)_r$	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 re 20 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.
$t(1)$，$t(2)$	s	*Time limit.* The beginning and end, respectively, of the noise time history defined by h.
Δt	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=10s.
$t(^oC)$ (^oF)	°C,°F	*Temperature.* The ambient air temperature.
$\alpha(i)$	dB/1000ft db/100m	Test atmospheric absorption. The atmospheric attenuation of sound that occurs in the i-th one-third octave band at the measured air temperature and relative humidity.
$\alpha(i)_0$	dB/1000ft db/100m	*Reference atmospheric absorption.* The atmospheric attenuation of sound that occurs in the i-th one-third octave band at a reference air temperature and relative humidity.
A_1	Degrees	First constant climb angle (Gear up, speed of at least V2+I0 kt (V2+19 km/h), takeoff thrust).
A_2	Degrees	Second constant climb angle (Gear up, speed of at least V2+I0 kt (V2+19 km/h), after cut-back).
δ ε	Degrees	*Thrust cutback angles.* The angles defining the points on the takeoff flight path at which thrust reduction is started and ended respectively.
η	Degrees	Approach angle.
η_r	Degrees	Reference approach angle.
θ	Degrees	*Noise angle (relative to flight path).* The angle between the flight path and noise path. It is identical for both measured and corrected flight paths.
ψ	Degrees	*Noise angle (relative to ground).* The angle between the noise path and the ground. It is identical for both measured and corrected flight paths.
μ		Engine noise emission parameter.

μ_r		**Reference engine noise emission parameter.**
Δ_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.**
Δ_2	**EPNdB**	***Adjustment to duration correction.*** **The adjustment to be made to the EPNL calculated from measured data to account for noise level changes due to the noise duration between reference and test conditions.**
Δ_3	**EPNdB**	***Source noise adjustment.*** **The adjustment to be made to the EPNL calculated from measured data to account for noise level changes due to differences between reference and test engine operating conditions.**

a. Explanation

This section contains standard noise symbols, their associated units, and the meaning of terms that are used during the testing, analysis, and evaluation of airplane noise certification.

b. Supplementary Information

(1) Common Symbols: Some of the airplane noise certification symbols identified in this section may also be common to other aircraft noise certification activities, such as the noise certification of small airplanes and rotorcraft.

c. Procedures

None.

232. Section A36.7 Sound Attenuation in Air

233. Section A36.7.1

The atmospheric attenuation of sound must be determined in accordance with the procedure presented in section A36.7.2.

234. Section A36.7.2

The relationship between sound attenuation, frequency, temperature, and humidity is expressed by the following equations.

A36.7.2(a) For calculations using the English System of Units:

$$\alpha(i) = 10^{\left[2.05\log(f_0/1000)+6.33\times10^{-4}\theta-1.45325\right]} + \eta(\delta)\times10^{\left[\log(f_0)+4.6833\times10^{-3}\theta-2.4215\right]}$$

and

$$\delta = \sqrt{\frac{1010}{f_0}}10^{\left(\log H-1.97274664+2.288074\times10^{-2}\theta\right)}\times10^{\left(-9.589\times10^{-5}\theta^2+3.0\times10^{-7}\theta^3\right)}$$

where

η(δ) is listed in Table A36-4 and f0 in Table A36-5;

α(i) is the attenuation coefficient in dB/1000 ft;

θ is the temperature in °F; and

H is the relative humidity, expressed as a percentage.

A36.7.2(b) For calculations using the International System of Units (SI):

$$\alpha(i) = 10^{\left[2.05\log(f_0/1000)+1.1394\times10^{-3}\theta-1.916984\right]} + \eta(\delta)\times10^{\left[\log(f_0)+8.42994\times10^{-3}\theta-2.755624\right]}$$

and

$$\delta = \sqrt{\frac{1010}{f_0}}10^{\left(\log H-1.328924+3.179768\times10^{-2}\theta\right)}\times10^{\left(-2.173716\times10^{-4}\theta^2+1.7496\times10^{-6}\theta^3\right)}$$

where

η(δ) is listed in Table A36-4 and f0 in Table A36-5;

α(i) is the attenuation coefficient in dB/100 m;

θ is the temperature in °C; and

H is the relative humidity, expressed as a percentage.

235. Section A36.7.3

The values listed in table A36-4 are to be used when calculating the equations listed in section A36.7.2. A term of quadratic interpolation is to be used where necessary.

Table A36-4. Values of $\eta(\delta)$

δ	η(δ)	δ	η(δ)
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 A36-5. Values 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

a. Explanation

This section specifies equations for calculating the atmospheric attenuation of sound.

b. Procedures

(1) Data Adjustment Procedures for Atmospheric Sound Attenuation Effects: Procedure (1) under section A36.2.2.3 and Procedure (2) under section A36.9.3.2.1 of this AC provide example procedures (using the equations given in section A36.7.2) to adjust noise certification data from test to reference conditions accounting for differences in atmospheric sound attenuation.

c. Procedures

None

236. Section A36.8. [Reserved]

237. Section A36.9. Adjustment of Airplane Flight Test Results

238. Section A36.9.1

When certification test conditions are not identical to reference conditions, appropriate adjustments must be made to the measured noise data using the methods described in this section.

a. Explanation

This section specifies methods for adjustment of noise data when test conditions differ from reference

conditions.

b. Supplemental Information

(1) Adjustments to Reference Conditions: Most noise certification tests are conducted during conditions other than the reference conditions. During these tests, the airplane may be at a different altitude (height over the microphone) or deviate laterally from the intended flight path. The engine thrust (power), atmospheric conditions, airplane altitude, and/or gross weight might also differ from reference conditions. Therefore, measured noise data must be adjusted to reference conditions to determine whether compliance with part 36, Appendix B, certification noise limits may be achieved. Adjustment procedures and analysis methods should be reviewed and approved by CAAC. Any changes, including

software revisions, firmware upgrades, or instrumentation changes are reviewed by the organization determined by the CAAC before they can be used for noise certification evaluations. Program validation should be planned and the required information submitted to the CAAC very early in the certification cycle, since the CAAC evaluation and approval may take longer than 18 months.

(2) Reference Conditions: Reference conditions are specified under section B36.7(a)(5).

(3) Ambient Noise Adjustments: See section A36.3.10 of this AC.

(4) Band-Dropping: FAA policy does not allow the implementation of band-dropping or band-elimination techniques. One-third octave band sound pressure levels are not to be set to zero, except as might normally occur as the result of calculations during the noise data evaluation process (for example, during frequency extrapolation of masked high-frequency band levels).

(5) Minimum Approach Distance: At the reference approach parameters of 394 feet altitude and 3 degree glide slope, the reference minimum distance equals 394 feet times the cosine of 3 degree, or 393.46 feet between the aircraft ILS antenna and the microphone measuring station.

(6) High Altitude Test Sites: For test sites at or above 1,200 feet (366 meters), data must be adjusted to account for jet noise suppression due to the difference in the engine jet velocity and jet velocity shear effects resulting from the change in air density. This adjustment is described in Appendix 6 of the appended ICAO TM.

c. Procedures

(1) Data Adjustments: The applicant is to adjust all measured data to certification reference conditions by CAAC-approved procedures. The applicant must submit all proposed data adjustment procedures to CAAC for review and approval. The CAAC may require submittal of extensive detailed information about the data adjustment process and analysis methods for evaluation and acceptance.

(2) CAAC Evaluations: Appendix 2 of this AC provides the information and forms that an applicant may use to submit noise, airplane tracking, and meteorological measurement data to the FAA for evaluation and approval of the applicant’s noise certification data adjustment and analysis methods.

(3) NPD Database: To facilitate data adjustments, many applicants convert

measured noise certification test data into a Noise Power Distance (NPD) database as an equivalent procedure. The NPD database should be constructed utilizing data that are representative of reference conditions. For example, the selected NPD airspeed must be representative of the range of airspeeds for the configurations and gross weights which are anticipated to be used for reference conditions. Similar adjustments can be made to test conditions for distance, airplane altitude, engine thrust (power) and atmospheric sound attenuation to create a useful NPD database. Then, when the reference airspeed and other reference conditions are identified and approved, final noise adjustments can easily be made to the NPD database values to obtain reference EPNL values.

(4) Applicant's Responsibility: The applicant is responsible for

(i) Making data adjustments in accordance with a CAAC approved noise demonstration compliance plan

(ii) Ensuring version control of all noise data analysis software and informing the cognizant CAAC of all revisions.

239. Section A36.9.1.1

Adjustments to the measured noise values must be made using one of the methods described in sections A36.9.3 and A36.9.4 for differences in the following:

(a) Attenuation of the noise along its path as affected by "inverse square" and atmospheric attenuation

(b) Duration of the noise as affected by the distance and the speed of the airplane relative to the measuring point

(c) Source noise emitted by the engine as affected by the differences between test and reference engine operating conditions

(d) Airplane/engine source noise as affected by differences between test and reference airspeeds. In addition to the effect on duration, the effects of airspeed on component noise sources must be accounted for as follows: for conventional airplane configurations, when differences between test and reference airspeeds exceed 28 km/h (15 knots) true airspeed, test data and/or analysis approved by the CAAC must be used to quantify the effects of the airspeed adjustment on resulting certification noise levels.

a. Explanation

This section specifies the types of differences between test and reference conditions that require adjustment of measured noise values.

b. Supplemental Information

(1) Test Atmospheric Conditions: Noise certification tests are rarely, if ever, conducted during atmospheric conditions that comply with reference conditions (i.e., sea level ambient pressure, 77º Fahrenheit and 70 percent relative humidity).

(2) Sound Propagation: The sound that propagates along the path between an airplane and the noise measurement points is affected by the meteorological conditions of the air through which the sound passes. Temperature and relative humidity affect the atmospheric sound attenuation of transmitted source noise. Noise test data are to be adjusted to reference conditions using an CAAC-approved procedure.

(3) Homogeneous Path: Reference atmospheric conditions (see section B36.7(a)(5)) along the propagation path are considered homogeneous (uniform in nature and composition). The reference conditions are sea level (pressure altitude), 77° Fahrenheit temperature, a constant 70 percent relative humidity and zero wind.

(4) Required Adjustments of Noise Values: Measured noise values must be adjusted to the reference ambient temperature and relative humidity conditions specified in part 36 and to reference airplane position and engine performance conditions. Reference airplane position and engine performance conditions must be derived using CAAC-approved airplane performance data at the reference ambient conditions. These adjustments account for the effects of atmospheric sound attenuation, sound propagation distance, airplane speed, and airplane source noise.

(5) Effect of Airspeed on Source Noise: Sections 2.3.4.7 and 2.3.4.9 of the appended ICAO TM provide guidance on the effect that airspeed has on airplane source noise. Applicants must obtain CAAC approval for adjustment methods to account for the effect that airspeed has on source noise (e.g., when differences between test and reference airspeeds exceed 28 km/h (15 knots) true airspeed).

(6) Other Adjustments to Noise Values: Part 36 is intended to produce accurate, repeatable, and comparable values of $EPNL_r$. Some adjustments inherent in the CAAC approval of equivalent procedures may also apply to the overall adjustment of noise values from test to reference conditions. These

adjustments may account for:

(i) Airplane flight path altitude;

(ii) Airplane flight path climb or descent angle;

(iii) Airplane airspeed;

(iv) Extrapolation of adjusted data for an NPD data base;

(v) Airplane configurations (or modifications) that differ from the reference airplane;

(vi) Background noise levels;

(vii) Engine thrust (power) setting;

(viii)Spectral irregularities;

(ix) Cutback thrust (power) application;

(x) Instrument and equipment calibrations;

(xi) Pseudo-tones.

(7) Manufacturer’s Data: Adjustment of noise values from test to reference conditions should be based on CAAC-approved manufacturer's data. Manufacturer's data may include:

(i) Reference flight profiles during take-off with maximum gross weight;

(ii) Flyover, lateral, and approach engine thrust (power) or thrust settings at reference conditions;

(iii) Engine cutback thrust (power) requirements at reference flyover conditions;

(iv) Data defining negative runway gradients;

(v) Reference airspeeds during flyover, lateral, and approach tests at maximum gross weights.

c. Procedures

(1) Applicant’s Responsibility: The applicant is responsible for

(i) Developing and obtaining CAAC approval of noise data including those associated with equivalent procedures.

(ii) Obtaining CAAC approval of noise data adjustment procedures and

analysis methods.

(iii) Applying approved noise data adjustments used to determine values of $EPNL_r$.

(iv) Documenting adjustment procedures not specifically identified in part 36.

240. Section A36.9.1.2

The "integrated" method of adjustment, described in section A36.9.4, must be used on takeoff or approach under the following conditions:

(a) When the amount of the adjustment (using the "simplified" method) is greater than 8 dB on flyover, or 4 dB on approach; or

(b) When the resulting final EPNL value on flyover or approach (using the simplified method) is within 1 dB of the limiting noise levels as prescribed in section B36.5 of this part.

a. Explanation

None.

b. Supplemental Information

(1) Simplified and Integrated Methods: When testing is conducted at other than reference conditions, noise data must be adjusted to reference conditions by one of the following methods:

(i) The simplified analysis procedure, whereby the PNLTM value of the lateral, flyover, and/or approach noise measurement is adjusted to reference conditions

(ii) The integrated analysis procedure whereby, each half-second spectrum of noise measurements throughout the 10 dB-down period is adjusted to reference conditions. The noise emission angle is kept constant in determining the reference emission time that corresponds to the test emission time. The use of the integrated procedure is not required by part 36 for adjustment of lateral noise data.

c. Procedures

(1) NPD Equivalent Procedures: Applicants that propose the use of NPD databases may be required to use the integrated method as part of an equivalent

procedure approval process. Appropriate noise data adjustments from test to reference conditions must be incorporated into the integrated method prior to comparing values of $EPNL_r$ to the limits specified in Appendix B.

241. Section A36.9.2 Flight profiles.

As described below, flight profiles for both test and reference conditions are defined by their geometry relative to the ground, together with the associated airplane speed relative to the ground, and the associated engine control parameter(s) used for determining the noise emission of the airplane.

242. A36.9.2.1 Takeoff Profile.

Note: Figure A36-4 illustrates a typical takeoff profile.

(a) The airplane begins the takeoff roll at point A, lifts off at point B and begins its first climb at a constant angle at point C. Where thrust or power (as appropriate) cut-back is used, it is started at point D and completed at point E. From here, the airplane begins a second climb at a constant angle up to point F, the end of the noise certification takeoff flight path.

(b) Position K_1 is the takeoff noise measuring station and AK_1 is the distance from start of roll to the flyover measuring point. Position K_2 is the lateral noise measuring station, which is located on a line parallel to, and the specified distance from, the runway center line where the noise level during takeoff is greatest.

(c) The distance AF is the distance over which the airplane position is measured and synchronized with the noise measurements, as required by section A36.2.3.2 of this part.

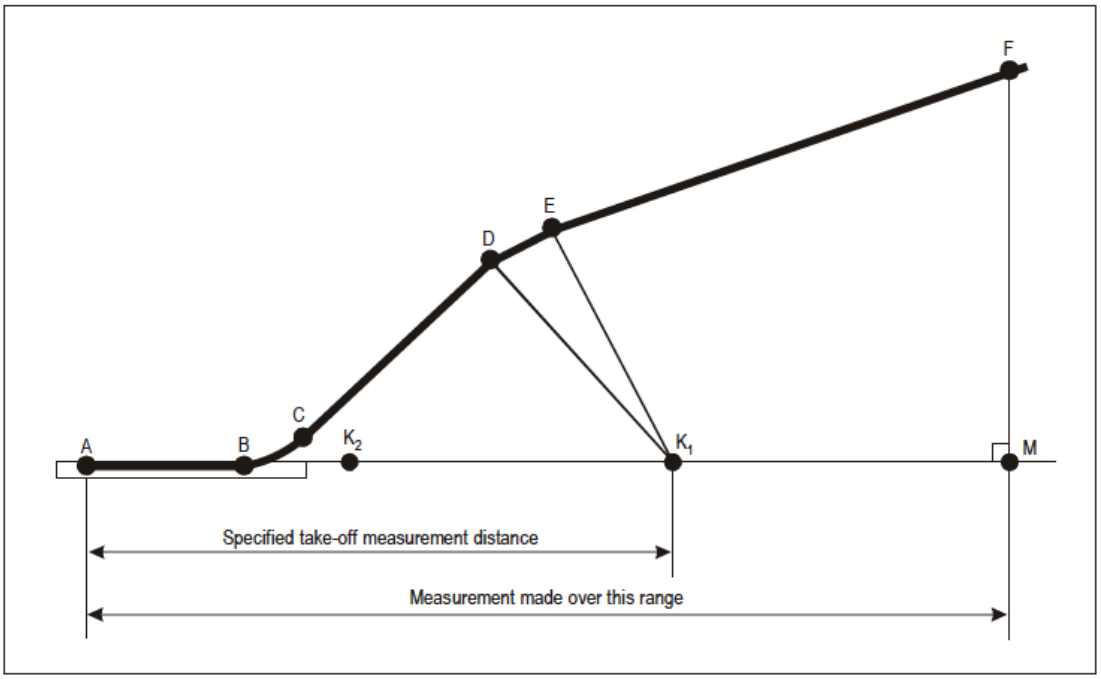


Figure A36-4. Typical take-off profile

a. Explanation

This section specifies the take-off flight test profiles for flyover noise measurements.

b. Supplemental Information

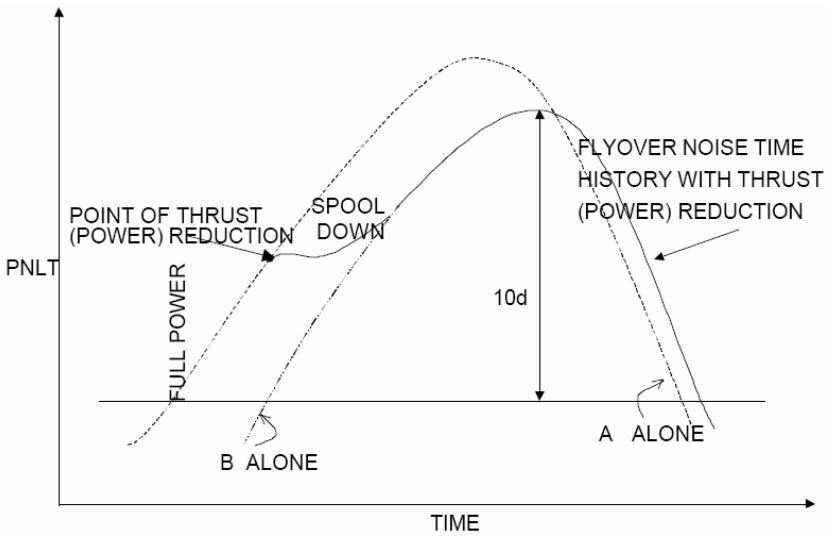
(1) Take-off Tests: The reference take-off configuration selected by the applicant must be within the approved airworthiness certification envelope. Special flight crew procedures or aircraft operating procedures are not permitted. The following figures explain the approved takeoff procedures used during noise certification flight testing for subsonic transport category large airplanes and jet airplanes.

(2) Take-offs with Thrust (Power) Reduction: Take-offs with thrust (power) reduction are permitted to be included in the reference flyover noise certification procedure (and in the reference lateral noise certification procedure for tests conducted before April 15, 2007) for subsonic transport category large airplanes and jet airplanes, regardless of category (see Figure A36.4). Maximum average engine take-off thrust (power) must be used from the start of take-off roll to the minimum altitude for initiation of thrust (power) reduction as specified in section B36.7(b); see the table below. Section B36.7(b)(2) limits the thrust (power) reduction to the greater of: (a) that required to maintain one-engine-inoperative level flight, or (b) that required to maintain 4 percent

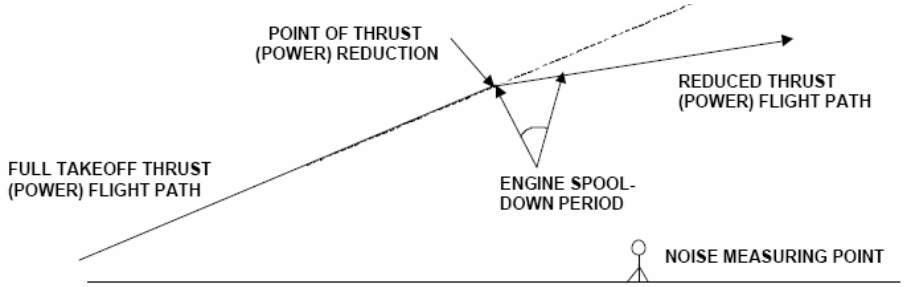
climb gradient with all engines operating. After thrust (power) reduction a slight decrease in the climb gradient may occur due to the thrust lapse that results from increased altitude during the 10 dB-down period. Figure 2 illustrates an example of the effect of thrust (power) reduction on the PNLT time history.

(3) Minimum Altitude for Thrust (Power) Reduction: During take-off, the engine thrust (power) may be reduced after the minimum altitude has been reached. The minimum thrust (power) reduction altitudes are given below:

Stage	Number of Engines	Bypass Ratio	Minimum Thrust (Power) Reduction Altitude
1	a. More than 3 turbojet engines	a. All bypass ratios	a. 214 m (700 ft)
	b. 3 or fewer turbojet engines	b. All bypass ratios	b. 305 m (1,000 ft)
	c. Not powered by turbojet engines	c. Not applicable	c. 305 m (1,000 ft)
2	a. More than 3 turbojet engines	a. Less than 2.0	a. 214 m (700 ft)
	b. 3 or fewer turbojet engines	b. Less than 2.0	b. 305 m (1,000 ft)
	c. More than 3 turbojet engines	c. 2.0 or more	c. 689 ft (210 m)
	d. 3 turbojet engines	d. 2.0 or more	d. 853 ft (260 m)
	e. Fewer than 3 turbojet engines	e. 2.0 or more	e. 984 ft (300 m)
	f. Not powered by turbojet engines	f. Not applicable	b. 305 m (1,000 ft)
3	a. More than 3 engines	a. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	a. 689 ft (210 m)
	b. 3 engines	b. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	b. 853 ft (260 m)
	c. Fewer than 3 engines	c. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	c. 984 ft (300 m)



2(A) TAKE-OFF NOISE TIME HISTORY



2(B) TAKE-OFF FLIGHT PATH OVER FLYOVER MEASURING POINT WITH THRUST (POWER) REDUCTION

Figure 2: Noise Time History with Thrust (Power) Reduction

(4) Full Thrust (Power) Take-offs: Full Thrust (power) take-offs are also permitted as the reference flyover noise certification procedure and are required for the lateral noise certification procedure for tests conducted on or after April 15, 2007 (see sections B36.3 and B36.7(b)(3)). Maximum approved take-off Thrust (power) is to be used from the start of roll (Point A) at one end of a runway (Figure 3). Liftoff from the runway is at Point B, after which the landing gear is stowed, and flap positions adjusted. At Point C, the stabilized climb angle and airspeed are achieved while maintaining full take-off thrust (power). The airplane continues to climb until sufficiently past (Point F) to ensure that the 10 dB-down time noise value is measured at point K. Between Points C and F, the thrust (power), flight path and aircraft configurations are to be kept constant.

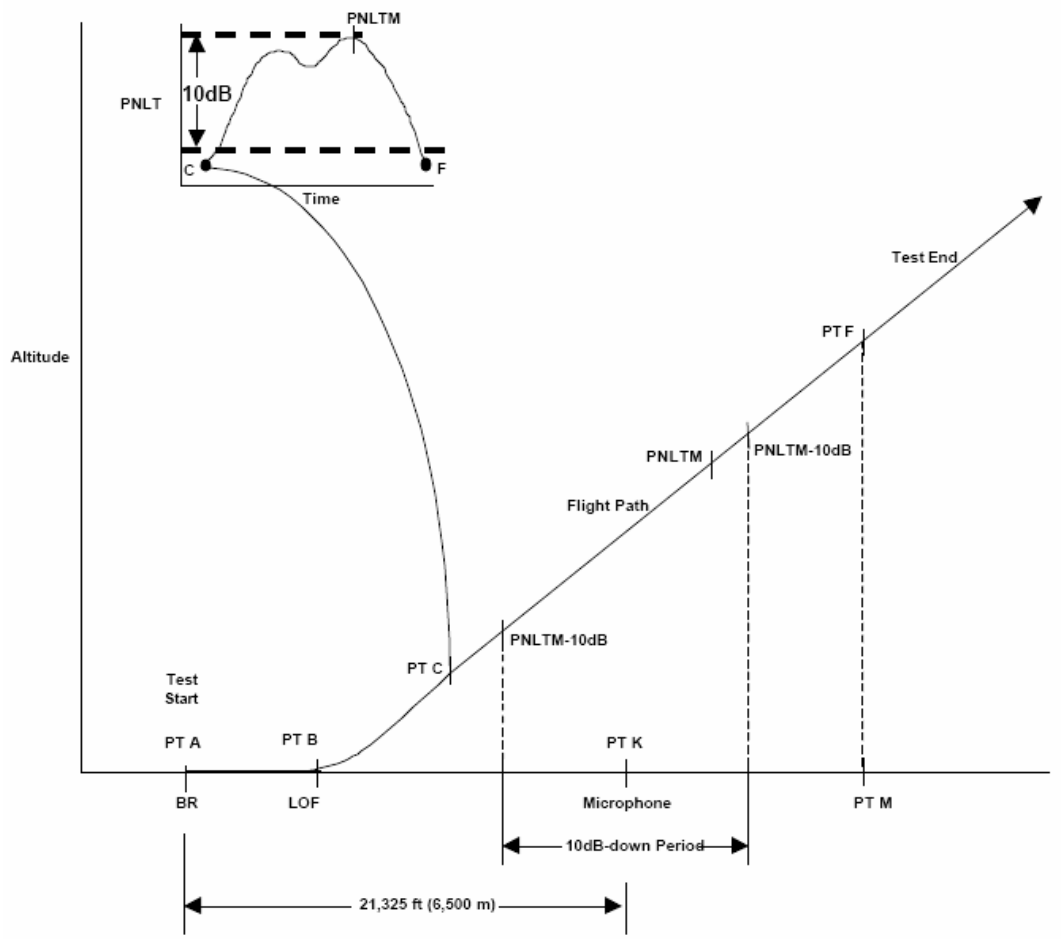


Figure 3: Normal Full Thrust (Power) Take-Off

(5) Flight Path Intercept Take-off: The flight path intercept procedure is permitted as an equivalent procedure for take-off noise certification testing (Figure 4). Under this equivalent procedure, noise certification test runs may be conducted with the airplane "intercepting" the relevant portion of the noise certification flight test path. This procedure is used in lieu of performing an actual landing and takeoff for each test run. When using the flight path intercept procedure, the airplane test flight path, pitch, airspeed, thrust (power), etc., are to be identical to those that would have existed had the applicant conducted the take-off noise certification test from a static condition on the runway. See sections 2.1.1 and 3.1.1 of the appended ICAO TM.

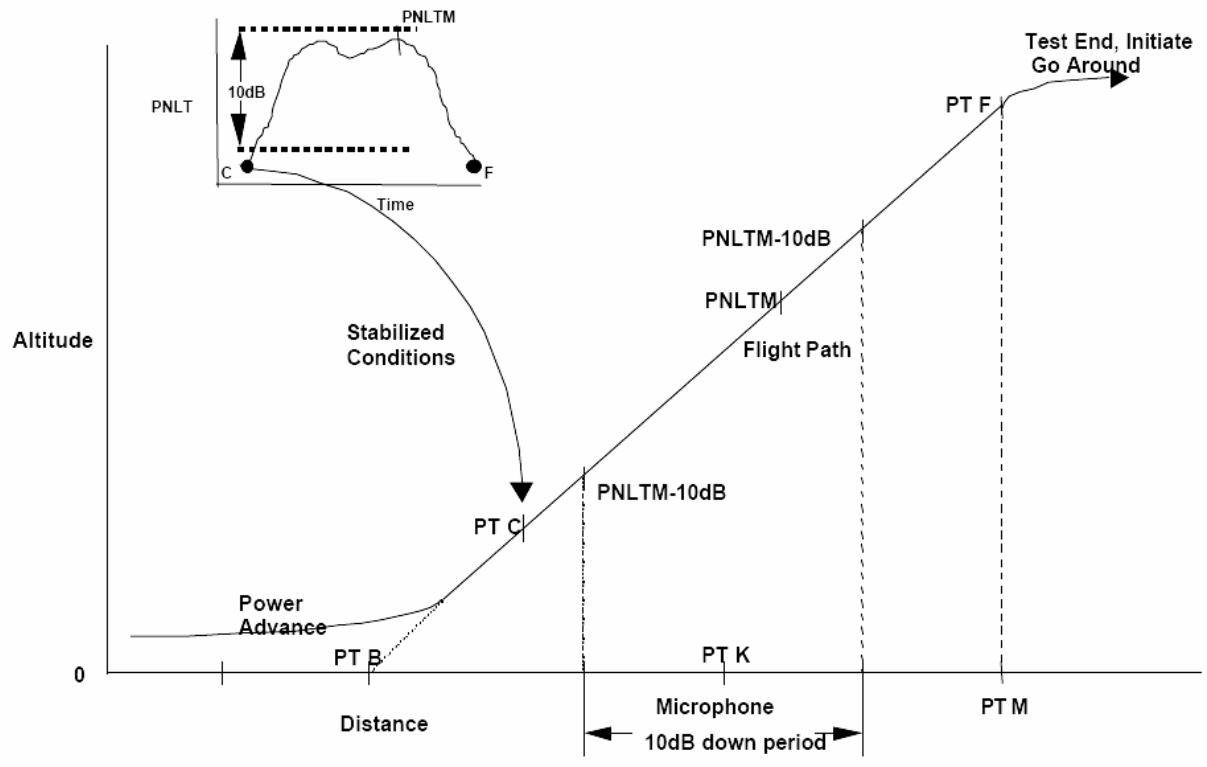


Figure 4: Flight Path Intercept Take-Off

(6) Flight Path: Figure 5 illustatrates the flight path tolerance for envelope within which the flight crew can fly between Points C and F. The FAA permits a ±20 percent tolerance in overhead test altitude and a ±10° lateral tolerance relative to the extended runway centerline. These tolerances permit the applicant to conduct testing during most wind conditions with minimal risk of re-testing being required due to off-target flight paths. In conjunction with the climb gradient and approach angle, these flight path deviation limitations define the takeoff "flight path" through which the aircraft is to fly during and throughout the noise measurements (during 10 dB-down period). During flyover and lateral noise measurements, the extended centerline is not visible and it may be more difficult to conduct flight within the approved flight path, especially during conditions of anomalous winds aloft. Several methods have been devised to assist, and provide direction to the flight crew in order to stay within the required flight path envelope. Indicators located in the airplane cockpit can provide flight path direction and indicate deviations from the extended runway centerline. Transmissions from the airplane position-indicating system (e.g., microwave position system, precision DMU, or DGPS) can also provide useful inputs.

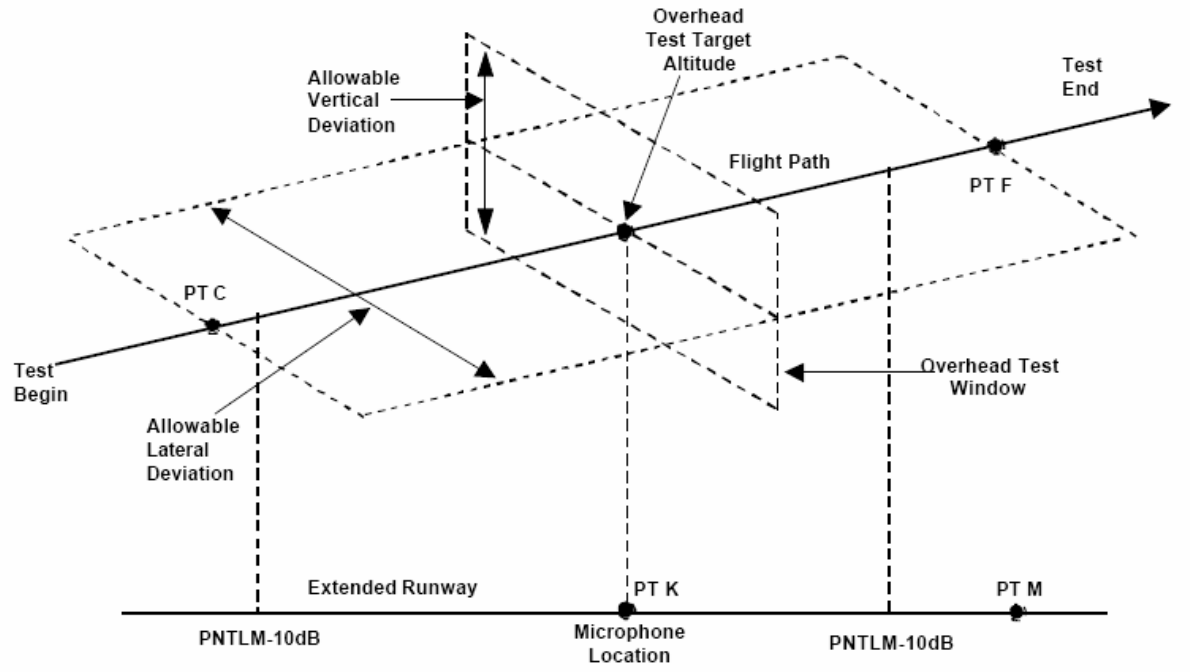


Figure 5: Take-Off Flight Path

c. Procedures

(1) Target Test Conditions: Target test conditions are established for each noise measurement. These target conditions specify the flight procedure, aerodynamic configuration to be selected, airplane weight, engine thrust (power), airspeed, and, at the closest point of approach to the noise measurement point, airplane altitude. Regarding choice of target airspeeds and variation in test weights, the possible combinations of these test elements may affect the airplane angle-of-attack or airplane altitude and therefore possibly the airplane noise generation or propagation geometry. See sections 2.1.2.1 and 3.1.2(a) of the appended ICAO TM for guidance on the choice of target airspeeds and variation in test weights.

(2) Simulated Thrust (Power) Reduction Evaluation: When thrust (power) reduction, as permitted under section B36.7(b), is used in conjunction with establishing the flyover noise certification level (or lateral noise certification level for tests conducted before April 15, 2007), a commonly used equivalent procedure allows for the noise certification level to be determined through the coupling of the NPD database with the approved engine spool-down data. As long as the minimum thrust (power) reduction height requirements specified in section B36.7(b)(1) are met, the thrust (power) reduction initiation height may

be selected to ensure stabilized thrust (power) reduction conditions before the initial 10 dB-down point. As discussed in section 2.2.1.2 of the appended ICAO TM, this procedure can be implemented using constant stabilized thrust (power) throughout the 10 dB-down period. Flyover noise levels with thrust (power) reduction may also be established from the merging of PNLT versus time measurements obtained during constant thrust (power) operations. The 10 dB-down period may contain portions of both the full thrust (power) and reduced thrust (power) noise time histories. Section 2.2.1.1 of the appended ICAO TM describes the establishment of the flyover noise certification level when the 10-dB down PNLT noise time history contains portions of both full thrust (power) and reduced thrust (power). The CAAC must witness and approve all engine spool-down testing. See section B36.7(b)(1) for additional information regarding engine spool-down testing.

(3) Flight Test Procedures: Before the start of noise testing the FAA must approve flight path tolerances (see Supplemental Information Item 6 under this section). Between Points C and F (Figure 5), the engine thrust (power), airplane flight path and aerodynamic configuration must be kept constant during each approved certification flight test (except when take-offs with thrust (power) reduction are being demonstrated).

(4) Invalid Test Data: Noise measurements obtained when the airplane flies outside the approved flight path envelope between Points C and F (Figure 5) during a noise certification test are considered invalid, and the noise measurement is to be repeated.

243. Section A36.9.2.2 Approach Profile

Note: Figure A36-5 illustrates a typical approach profile.

(a) The airplane begins its noise certification approach flight path at point G and touches down on the runway at point J, at a distance OJ from the runway threshold.

(b) Position K_3 is the approach noise measuring station and K_3O is the distance from the approach noise measurement point to the runway threshold.

(c) The distance GI is the distance over which the airplane position is measured and synchronized with the noise measurements, as required by section A36.2.3.2 of this part.

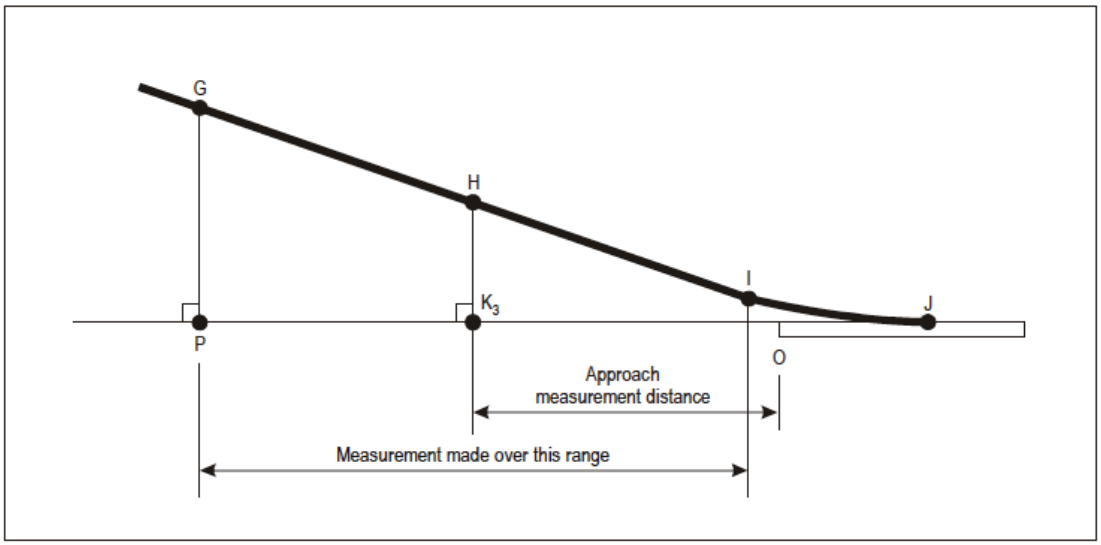


Figure A36-5. Typical approach profile

a. Explanation

This section provides illustrations and explanations of approach flight test profiles .

b. Supplemental Information

(1) Approach Tests: Figures 6 and 7 depict the types of approved approach flight test procedures used during noise certification testing for subsonic transport category large airplanes and jet airplanes. The approach angle (steady glide angle) for this condition is 3° ± 0.5°, and the target airplane height vertically over the noise measurement point is 394 feet. Figure 8 illustrates the allowable approach flight test path deviations. Maximum PNLT may occur before or after the approach noise measurement point.

(2) Normal Approach Flight Tests: Part 36 specifies a full landing following each approach noise measurement (Figure 6). This type of flight test is less efficient than the flight path intercept equivalent procedure that is used by most noise certification applicants. See sections 2.1.1 and 3.1.1 of the appended ICAO TM for more guidance on the use of the flight intercept procedure.

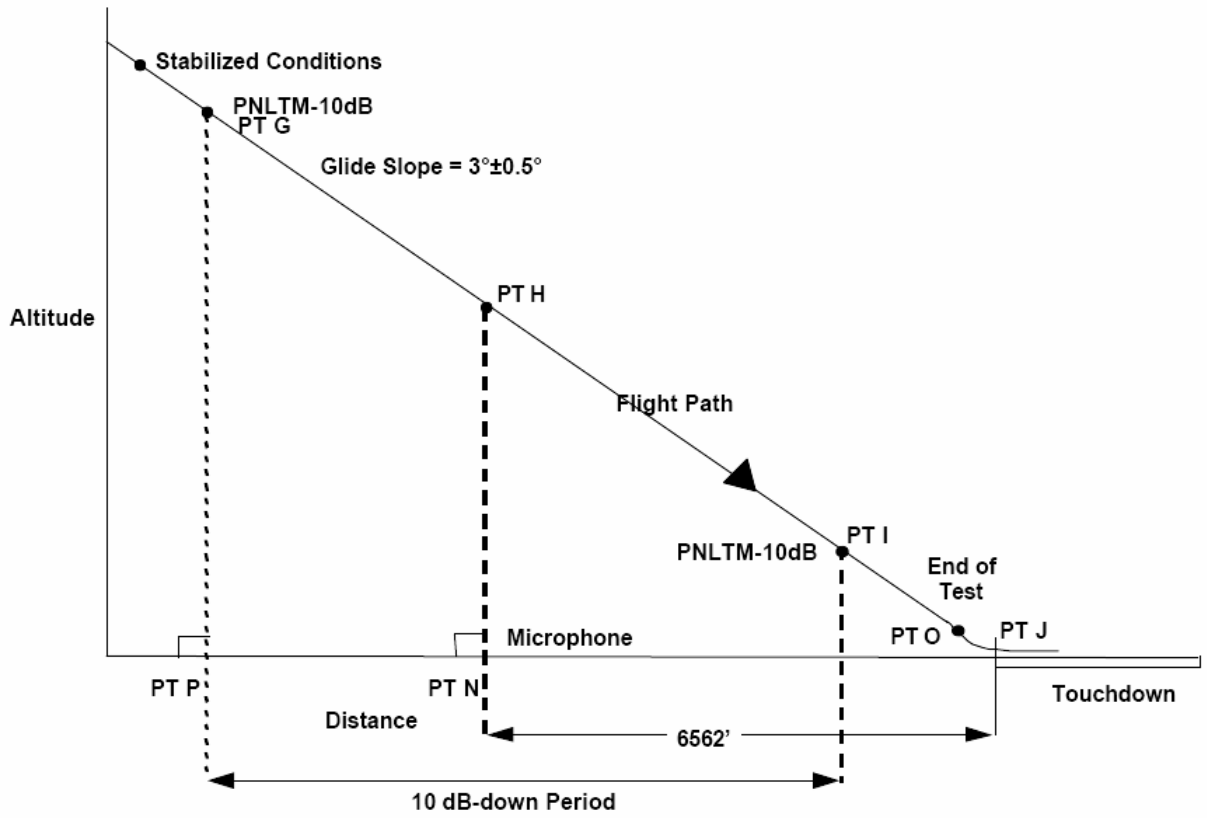


Figure 6: Approach with Full Landing

(3) Flight Path Intercept Approaches: When the flight path intercept procedure is used for approach, the airplane does not land, but following the determination that the 10 dB-down time requirements have been satisfied, initiates a go-around maneuver and returns to the in-flight setup location for the next test condition (Figure 7). Most applicants use the flight path intercept procedure for approach flight testing. This procedure permits the applicant to remain flying during acceptable atmospheric conditions without the delays associated with landings and take-offs.

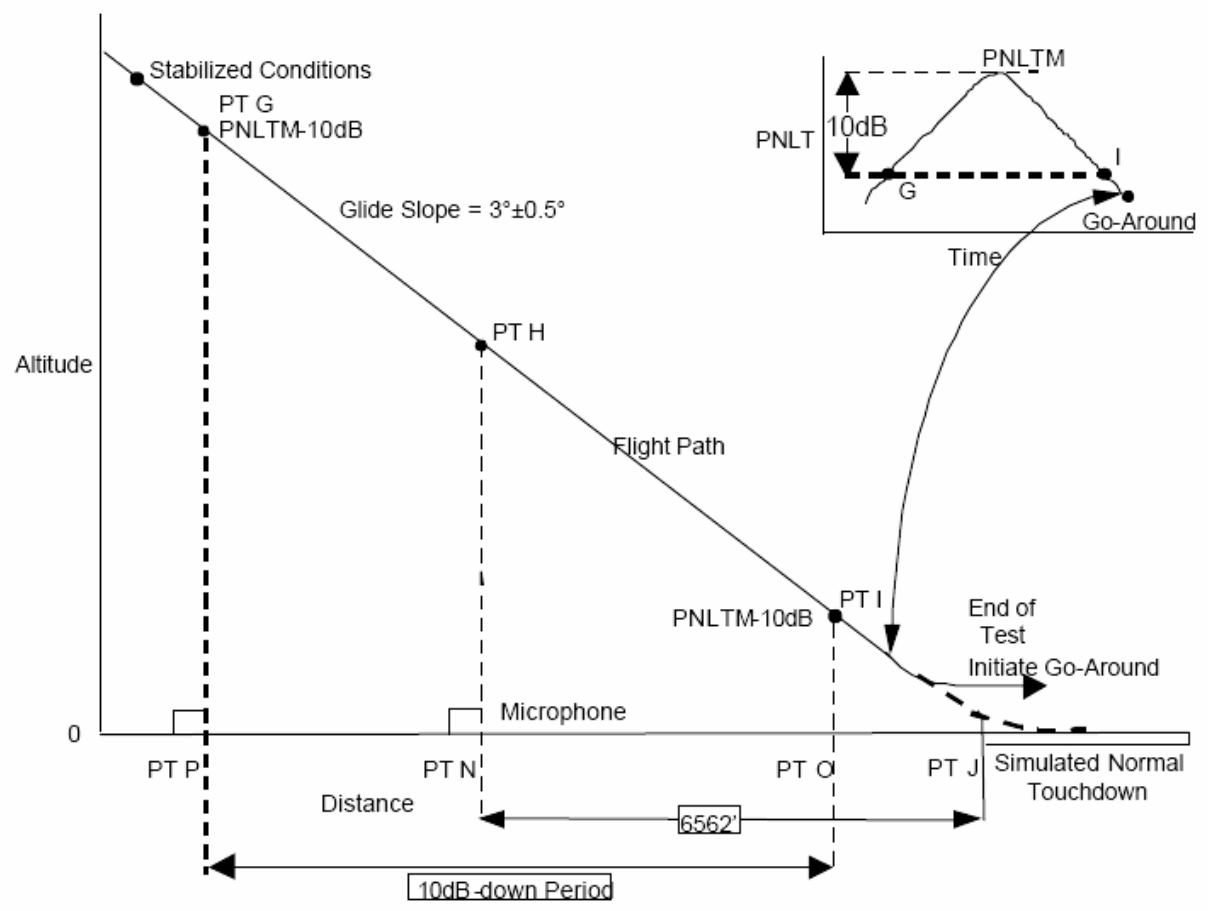


Figure 7: Flight Path Intercept Approach

(4) Flight Path Deviations: Approved altitude and centerline deviations along the extended runway approach flight path (Figure 8) define an approved flight path envelope within which the flight crew can fly between Points G and I (see Supplemental Information under Item 6 section A36.9.2.1). Since the flight crew has a clear view of the airport runway during approach conditions, it is normal for the crew to consistently fly within the approved flight path envelope. Therefore, the approved centerline and altitude deviations for approach conditions may be smaller than during take-off conditions.

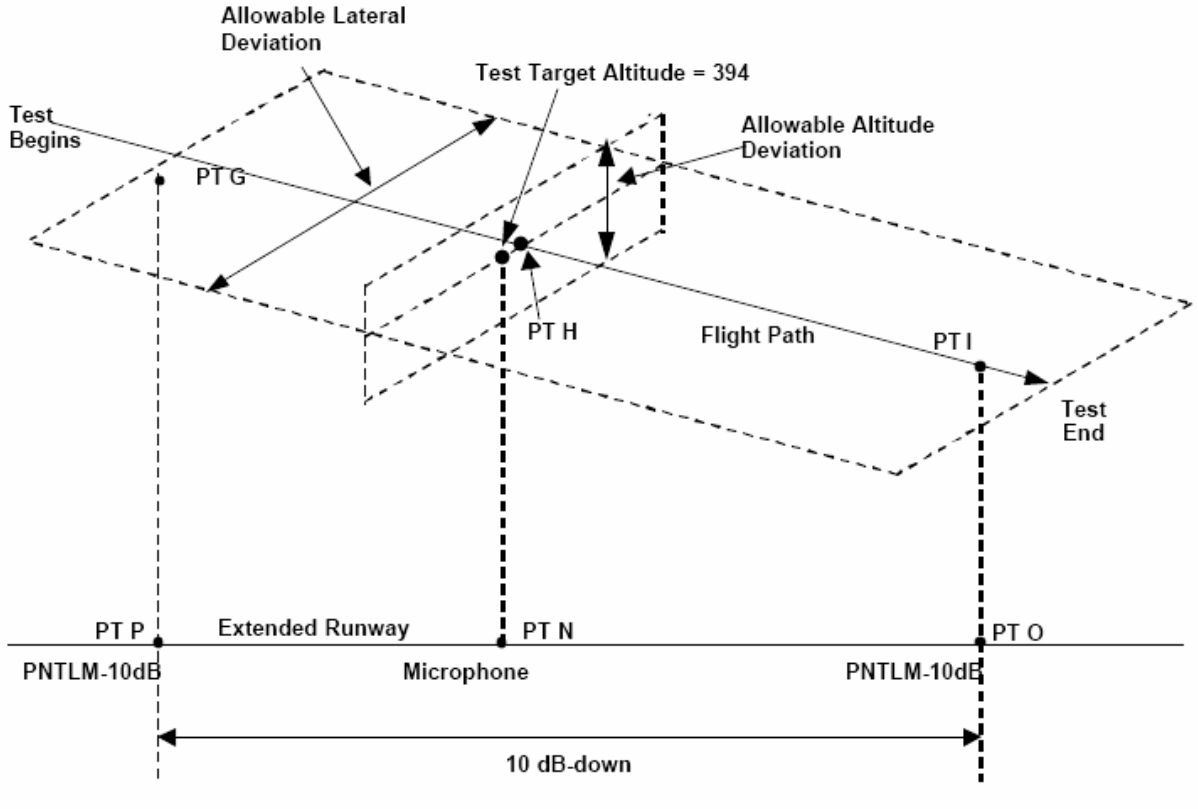


Figure 8: Approach Flight Path Deviations

c. Procedures

(1) Noise-Power-Distance Database: By developing an approach noise-power-distance database, the applicant can obtain noise certification data to cover a range of airplane weights and engine thrust (power) settings. The NPD method is an equivalent procedure and must be approved by the CAAC prior to its use. In developing an NPD database, noise data may be obtained with a series of different engine thrust (power) settings down to in-flight idle thrust (power). The NPD database can then be used to determine reference condition approach noise levels. Stabilized thrust (power) (Point G in Figure 7) is set before the initial 10 dB-down point and maintained until the subsequent 10 dB-down point has passed (Point I). The applicant must take care to obtain enough thrust (power) settings to permit a second or third order curve fit through the generalized data, and to define data shifts that may be caused by engine internal compressor bleed operations. In creating an NPD database, it will not be possible to maintain all of the constant constraints of weight, airspeed, thrust (power), configuration glide path, and height over the microphone. The critical test parameters to be maintained are constant thrust (power) and configuration during the test condition. The glide angle during the NPD test shall be that which results from the aircraft conditions (i.e., weight, configuration, airspeed,

and engine thrust (power)). See sections 2.1.2 and 3.1.2 of the appended ICAO TM.

(2) Target Test Conditions: Target test conditions must be established for each noise measurement. These specify the selected aerodynamic configuration, system operation, airplane weight, flight procedure (such as complete landings or flight path intercepts), altitude, thrust (power), and airspeed during each overflight. The applicant is required to select the approved airworthiness configuration for the approach noise certification that produces the highest noise level (i.e., the most critical from the standpoint of noise). Airspeed is generally held to within ± 3.0 percent of the average airspeed during the 10 dB-down measuring period. The airplane configuration (e.g., flap setting, A/C, and/or APU system operation) is to remain constant during the noise measurement period. Airspeed variations are measured in indicated airspeed determined by the pilot's airspeed indicator.

(3) Engine Idle Trim: For engines where the idle trim may affect the inter-compressor bleed valve schedule during the approach condition, the engine in-flight idle trim must be adjusted to the highest engine rpm setting permitted by the engine manufacturer and consistent with airworthiness requirements. The engine may also provide ground idle trim adjustment, but the trim that needs adjustment is that which is operable during flight. In-flight idle trim may be adjusted to improve engine acceleration characteristics to satisfy airworthiness compliance (e.g., with Part 25.119). The higher idle trim will cause the highest engine rpm (idle thrust (power)), which results in a greater airplane angle of attack, and will result in the loudest approach noise required for certification. The applicant is to make those adjustments necessary to satisfy the airworthiness regulations. This idle trim adjustment may affect the performance or evaluation of approach NPD testing.

(4) Internal Compressor Bleed Adjustment: The internal compressor bleed operation (sometimes referred to as the surge bleed valve (SBV) operation) must be adjusted within the engine manufacturer's specification to represent reference conditions as closely as possible. Most turbojet engines are equipped with internal compressor bleed systems. The internal compressor bleed operates to reduce the possibility of internal engine surges during rapid throttle movements. Some jet engines have overboard bleed systems that generate high noise levels. These systems normally operate above in-flight idle and do not present a problem unless the applicant chooses to prepare an NPD database and the thrust (power) settings higher than in-flight idle may be affected by the internal

compressor bleed operation. The applicant is responsible for substantiating that either (1) the internal compressor bleed operation does not affect the reference EPNL values during noise certification reference conditions, or (2) the data contains the effects of the internal compressor bleed operation.

(5) Flight Path Deviations: The approved approach flight path altitude and centerline deviations identify the tolerances of the flight path that are agreed on by the FAA and the applicant before the start of noise certification flight testing. Between Points G and I (see Figure 8), the engine thrust (power), system operational configuration, and aerodynamic configuration should be kept constant throughout the noise measurement (10 dB-down points).

(6) Approach Test Airspeed: The airspeed requirement for subsonic airplanes is V_{REF} + 10 knots. This airspeed is kept constant (within ±3.0 percent) between the approach measuring points (Points G and I in Figure 8). All test conditions should be conducted within 15 knots of the reference approach airspeed.

(7) Invalid Test Data: Noise measurements obtained when the aircraft flies outside the approved flight path envelope between Points G and I are invalid, and the noise measurement must be repeated.

244. Section A36.9.3 Simplified method of adjustment.

245. Section A36.9.3.1 General

As described below, the simplified adjustment method consists of applying adjustments (to the EPNL, which is calculated from the measured data) for the differences between measured and reference conditions at the moment of PNLTM.

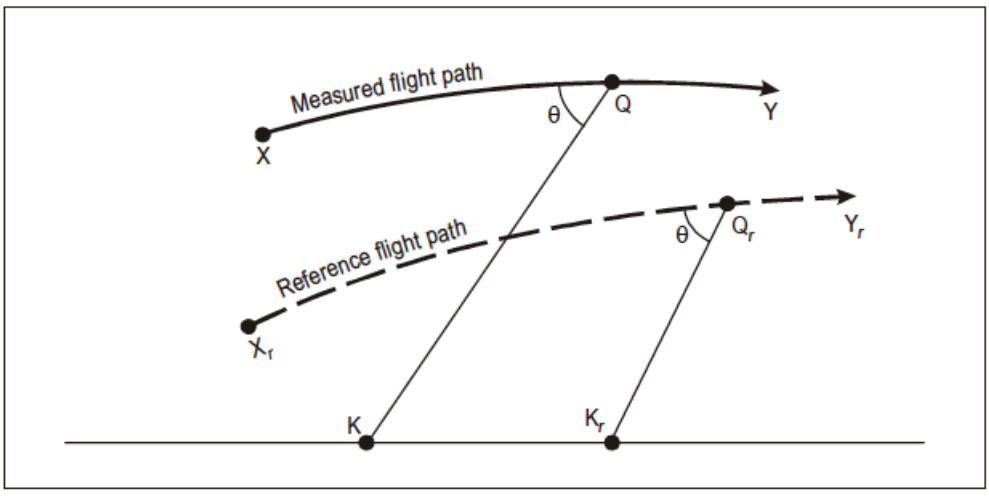


Figure A36-6. Profile characteristics influencing sound level

a. Explanation

This section specifies a methodology, known as the simplified method, for adjusting noise data from test to reference conditions. Use of this method for adjustment of take-off and approach noise data is limited by the criteria given in sections A36.9.1.2(a) and (b).

b. Supplemental Information

None

c. Procedures

None

246. Section A36.9.3.2 Adjustments to PNL and PNLT.

(a) The portions of the test flight path and the reference flight path described below, and illustrated in Figure A36-6, include the noise time history that is relevant to the calculation of flyover and approach EPNL. In figure A36-6:

(1) XY represents the portion of the measured flight path that includes the noise time history relevant to the calculation of flyover and approach EPNL; X_rY_r represents the corresponding portion of the reference flight path.

(2) Q represents the airplane's position on the measured flight path at which the noise was emitted and observed as PNLTM at the noise measuring station K. Q_r is the corresponding position on the reference flight path, and K_r the reference measuring station. QK and Q_rK_r are, respectively, the measured and reference noise propagation paths, Q_r being determined from the assumption that QK and Q_rK_r form the same angle θ with their respective flight paths.

(b) The portions of the test flight path and the reference flight path described in paragraph (b)(1) and (2), and illustrated in Figure A36-7(a) and (b), include the noise time history that is relevant to the calculation of lateral EPNL.

(1) In figure A36-7(a), XY represents the portion of the measured flight path that includes the noise time history that is relevant to the calculation of lateral EPNL; in figure A36-7(b), X_rY_r represents the

corresponding portion of the reference flight path.

(2) Q represents the airplane position on the measured flight path at which the noise was emitted and observed as PNLTM at the noise measuring station K. Q_r is the corresponding position on the reference flight path, and Kr the reference measuring station. QK and Q_rK_r are, respectively, the measured and reference noise propagation paths. In this case Kr is only specified as being on a particular Lateral line; K_r and Q_r are therefore determined from the assumptions that QK and Q_rK_r:

(i) Form the same angle θ with their respective flight paths; and

(ii) Form the same angle ψ with the ground.

Note: For the lateral noise measurement, sound propagation is affected not only by inverse square and atmospheric attenuation, but also by ground absorption and reflection effects which depend mainly on the angle ψ.

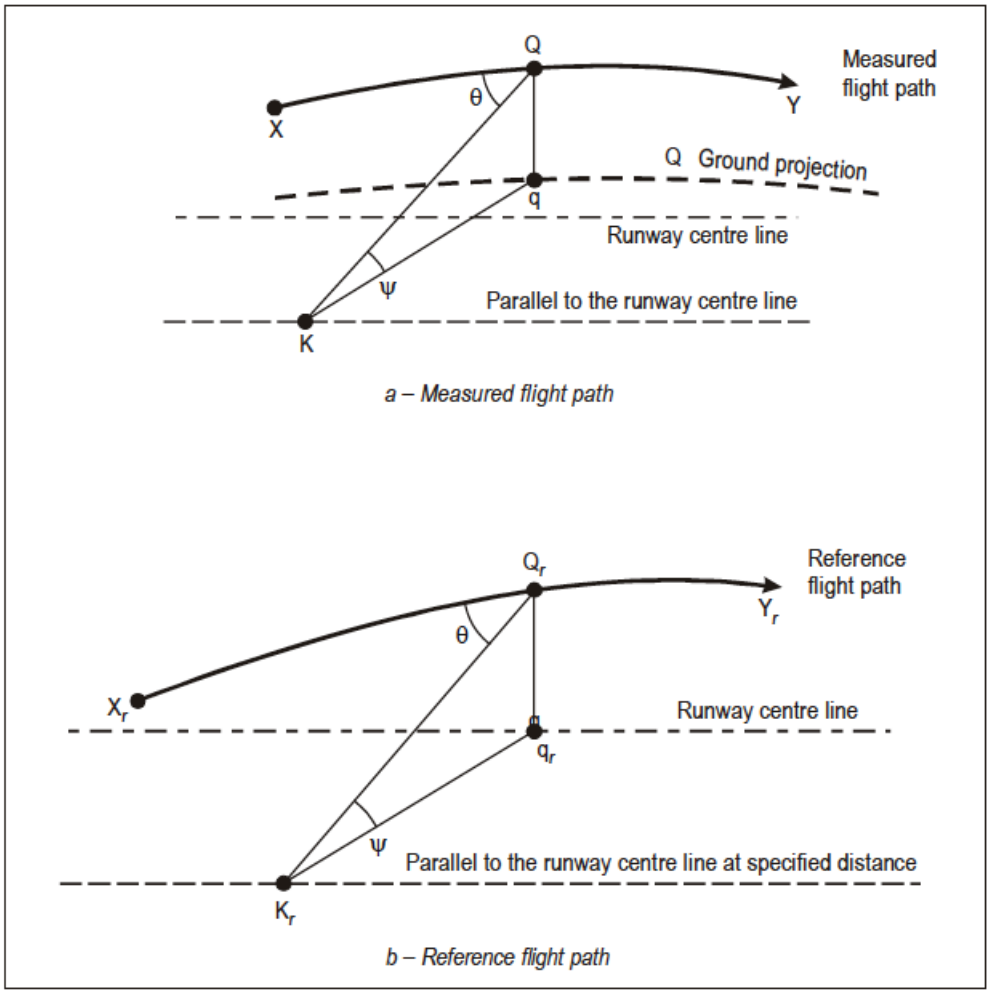


Figure A36-7. Lateral measurement — determination of reference station

a. Explanation

This section specifies the portions of flyover, lateral, and approach measured and reference flight paths that are relevant to the calculation of EPNL, and shows the symbols and geometry of the respective airplane positions, resulting noise angles, and sound propagation paths.

b. Supplemental Information

None

c. Procedures

None

247. Section A36.9.3.2.1

A36.9.3.2.1 The one-third octave band levels SPL(i) comprising PNL (the PNL at the moment of PNLTM observed at K) must be adjusted to reference levels SPL(i)r as follows:

A36.9.3.2.1(a) For calculations using the English System of Units:

$$SPL(i)_r = SPL(i) + 0.001[\alpha(i) - \alpha(i)_0]QK + 0.001\alpha(i)_0(QK - Q_rK_r) + 20\log(QK/Q_rK_r)$$

In this expression,

(1) The term $0.001[\alpha(i) - \alpha(i)_0]QK$ is the adjustment for the effect of the change in sound attenuation coefficient, and $\alpha(i)$ and $\alpha(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;

(2) The term $0.001\alpha(i)_0(QK - Q_rK_r)$ is the adjustment for the effect of the change in the noise path length on the sound attenuation;

(3) The term $20\log(QK/Q_rK_r)$ is the adjustment for the effect of the change in the noise path length due to the "inverse square" law;

(4) QK and Q_rK_r are measured in ft and $\alpha(i)$ and $\alpha(i)_0$ are expressed in dB/1000 ft.

A36.9.3.2.1(b) For calculations using the International System of Units:

$$SPL(i)r = SPL(i) + 0.01[\alpha(i) - \alpha(i)_0]QK + 0.01\alpha(i)_0(QK - Q_rK_r) + 20\log(QK/Q_rK_r)$$

In this expression,

(1) The term $0.01[\alpha(i) - \alpha(i)_0]QK$ is the adjustment for the effect of the change in sound attenuation coefficient, and $\alpha(i)$ and $\alpha(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;

(2) The term $0.01\alpha(i)0(QK - Q_rK_r)$ is the adjustment for the effect of the change in the noise path length on the sound attenuation;

(3) The term $20\log(QK/Q_rK_r)$ is the adjustment for the effect of the change in the noise path length due to the "inverse square" law;

(4) QK and Q_rK_r are measured in meters and $\alpha(i)$ and $\alpha(i)_0$ are expressed in dB/100 m.

a. Explanation

This section specifies the required adjustments to flyover, lateral, and approach one-third-octaveband sound pressure levels to account for the difference between test and reference conditions.

b. Supplemental Information

(1) Test and Reference Conditions: Most noise certification testing is accomplished at other than reference conditions (see section B36.7). When testing is conducted at conditions other than reference conditions, appropriate and approved adjustments are to be made to the measured noise data.

(2) Noise Emission Angles: The noise emission angle between the noise propagation path and the airplane flight paths must be equal for both test and reference evaluations.

(i) For the simplified method, the acoustical record at which PNLTM occurs during the noisemeasurement defines the test noise emission angle. This angle will then define the location along the reference flight path where PNLTr at time of PNLTM occurs.

c. Procedures:

(1) Calculation of Average Atmospheric Sound Attenuation Coefficients: When using a "layered" atmosphere, the average atmospheric sound attenuation coefficient, a(i), for each one-third octave band must be calculated by apportioning the coefficient values of the individual layers. The goal is to account for each layer's contribution to the atmospheric attenuation of sound

propagated through the layered atmosphere. Since propagation is assumed to occur in a straight line between the aircraft and the microphone, and since the proportion of the propagation distance through each layer is constant to the vertical distance through the layer, the average atmospheric sound attenuation coefficient through the layers can be determined using the aircraft altitude.

To determine the proper proportion of each layer's coefficient in the average value, first determine the aircraft altitude above the microphone. (In this case, at the time of PNLTM.) Then, determine the effective depth of each layer; that is, the vertical distance that the sound propagates through the layer. Next, for each layer, multiply the layer's atmospheric sound attenuation coefficient by the ratio of the layer's effective depth to the aircraft altitude above the microphone, and sum the resulting values.

Note that the full depth of the lowest (and in some cases, the highest) layer is not utilized. The depth of the lowest layer must have the microphone height subtracted. (i.e., for a nominal 100-foot layer, only 96 feet of vertical depth would affect the sound propagation to the four foot high microphone.) Also, unless the aircraft altitude coincides with the upper boundary of one of the layers, the layer containing the aircraft altitude will have only a partial effect on sound propagation.

(2) Example: Using the same layered atmospheric data presented in Procedure (1) under section A36.2.2.3 of this AC, and assuming an altitude above the ground at the microphone station (In this case, at the time of PNLTM,) of 394 feet, the average atmospheric sound attenuation coefficient for the 3150 Hz band would be 16. 79 dB per 1000 feet.

Layer Height, ft.	α (3150), dB/1000 ft.	Effective Layer Depth, ft.
Ground to 100	17.55	96 (100 minus 4)
100 to 200	17.15	100
200 to 300	16.63	100
300 to 400	15.81	94 (394 minus 300)

Table 4: Example - Effective Layer Depth

The effective depth of the lowest layer is 96 feet, since the layer is 100 feet high and the microphone extends four feet into the layer. The effective depths of the 2nd and 3rd layers are 100 feet each, since the sound propagates through the

full layer depth. The effective depth of the 4th layer is only 94 feet, since the aircraft altitude at the time of PNLTM is 394 feet, which is 94 feet above the lower boundary of the 4th layer.

(17.55 * 96 / 390) + 1st layer minus microphone height

(17.15 * 100 / 390) + Entire 2nd layer depth

(16.63 * 100 / 390) + Entire 3rd layer depth

(15.81 * 94 / 390) + Portion of 4th layer affecting propagation

= 16. 79 dB / 1000 feet Average atmospheric sound attenuation coefficient, 3150 Hz

This calculation is repeated to obtain the average atmospheric sound attenuation coefficient, for each one-third octave band. These values are then used in the calculation presented in section A36.9.3.2.1.

248. Section A36.9.3.2.1.1 PNLT Correction.

(a) Convert the corrected values, $SPL(i)_r$, to $PNLT_r$;

(b) Calculate the correction term Δ_1 using the following equation:

$$\Delta_1 = PNLT_r - PNLTM$$

a. Explanation

None

b. Supplemental Information

None

c. Procedures

(1) Application of BandSharing Adjustment for the "Simplified" Method: See the Supplemental Information and Procedures provided under section A36.4.4.2 of this AC.

(2) Application of High-Altitude Site Jet Noise Adjustment for "Simplified" Method: When the Equivalent Procedure for use of high-altitude test sites (Elevation > 1200 feet MSL) is employed, and when an adjustment has not been applied to measured one-third-octave-band sound pressure levels, SPL(i), the adjustment must be applied to the one-third-octave-band sound

pressure levels that have been adjusted to reference conditions, $SPL(i)_r$, before calculation of PNLTr at time of PNLTM and Δ_1. See Appendix 6 of the appended ICAO TM, for information on the equivalent procedure for testing at high-altitude sites.

249. Section A36.9.3.2.1.2

Add Δ_1 arithmetically to the EPNL calculated from the measured data.

250. Section A36.9.3.2.2

If, during a test flight, several peak values of PNLT that are within 2 dB of PNLTM are observed, the procedure defined in section A36.9.3.2.1 must be applied at each peak, and the adjustment term, calculated according to section A36.9.3.2.1, must be added to each peak to give corresponding adjusted peak values of PNLT. If these peak values exceed the value at the moment of PNLTM, the maximum value of such exceedance must be added as a further adjustment to the EPNL calculated from the measured data.

a. Explanation

None

b. Supplemental Information

(1) Identification of Multiple Peak PNLT Values: Peak PNLT values within 2 dB of PNLTM must be identified for use in the adjustment of test to reference EPNL values. This adjustment is calculated and applied as follows:

(i) For each identified peak value of PNLT, adjust the associated test condition one-third octave band spectrum to reference conditions, per the procedure described in section A36.9.3.2.1.

(ii) Subtract the PNLTr value at the time of PNLTM from each of the identified peak $PNLT_r$ values. If any of these differences is positive identify the largest value of exceedance.

(iii) Add this value (defined as Delta Peak) algebraically to the test EPNL value when determining the value of $EPNL_r$.

c. Procedures

None

251. Section A36.9.3.3 Adjustments to duration correction.

252. Section A36.9.3.3.1

Whenever the measured flight paths and/or the ground velocities of the test conditions differ from the reference flight paths and/or the ground velocities of the reference conditions, duration adjustments must be applied to the EPNL values calculated from the measured data. The adjustments must be calculated as described below.

a. Explanation

None

b. Supplemental Information

(1) Duration Adjustments: A duration adjustment must be determined when the simplified data analysis method is used. This adjustment, identified as Δ_2, accounts for the effect on duration due to: (1) the altitude difference between a test airplane flight path and a reference airplane flight path, and (2) due to the difference between a test airplane airspeed and a reference airplane airspeed. Δ_2 can be positive or negative.

c. Procedures

None

253. Section A36.9.3.3.2

For the flight path shown in Figure A36-6, the adjustment term is calculated as follows:

$$\Delta_2 = -7.5\log(QK/Q_rK_r) + 10\log(V/V_r)$$

Add Δ_2 arithmetically to the EPNL calculated from the measured data.

254. Section A36.9.3.4 Source noise adjustments.

255. Section A36.9.3.4.1

To account for differences between the parameters affecting engine noise as measured in the certification flight tests, and those calculated or specified

in the reference conditions, the source noise adjustment must be calculated and applied. The adjustment is determined from the manufacturer's data approved by the CAAC. Typical data used for this adjustment are illustrated in Figure A36-8 that shows a curve of EPNL versus the engine control parameter μ, with the EPNL data being corrected to all the other relevant reference conditions (airplane mass, speed and altitude, air temperature) and for the difference in noise between the test engine and the average engine (as defined in section B36.7(b)(7)). A sufficient number of data points over a range of values of μr is required to calculate the source noise adjustments for lateral, flyover and approach noise measurements.

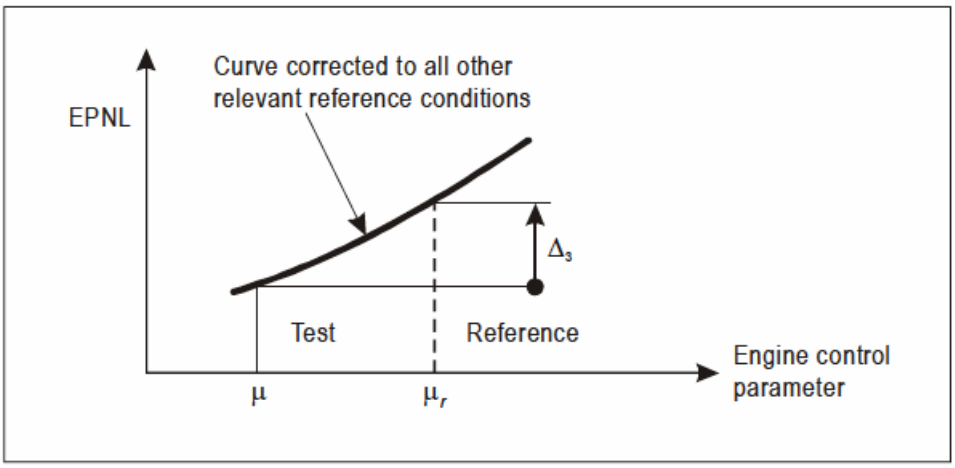


Figure A36-8. Noise thrust correction

256. Section A36.9.3.4.2

Calculate adjustment term Δ_3 by subtracting the EPNL value corresponding to the parameter μ from the EPNL value corresponding to the parameter μ_r. Add Δ_3 arithmetically to the EPNL value calculated from the measured data.

257. Section A36.9.3.5 Symmetry Adjustments.

258. Section A36.9.3.5.1

A symmetry adjustment to each lateral noise value (determined at the section B36.4(b) measurement points), is to be made as follows:

(a) If the symmetrical measurement point is opposite the point where

the highest noise level is obtained on the main lateral measurement line, the certification noise level is the arithmetic mean of the noise levels measured at these two points (see Figure A36-9(a));

(b) If the condition described in paragraph (a) of this section is not met, then it is assumed that the variation of noise with the altitude of the airplane is the same on both sides; there is a constant difference between the lines of noise versus altitude on both sides (see figure A36-9(b)). The certification noise level is the maximum value of the mean between these lines.

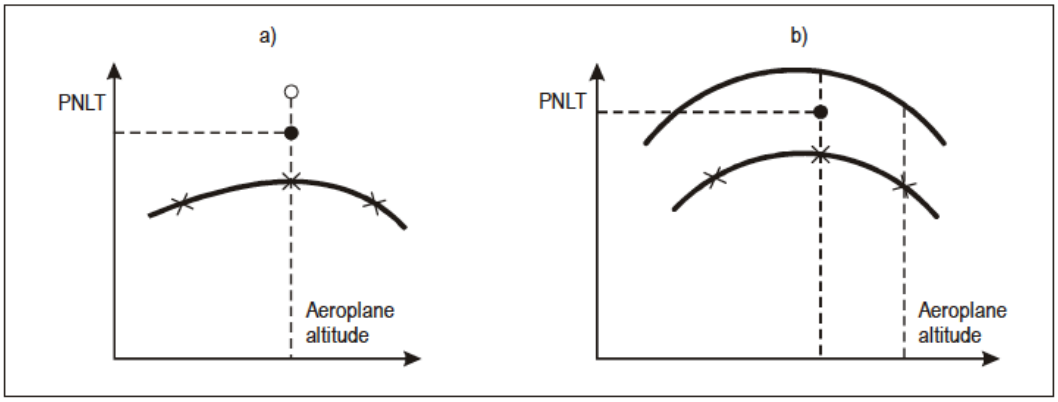


Figure A36-9. Symmetry correction

a. Explanation

This section specifies the methodology for applying a symmetry adjustment to the lateral noise levels determined for each test run.

b. Supplemental Information

(1) Guidance: Section 2.1.3 of the appended ICAO TM provides guidance on determination of lateral noise certification levels.

(2) Measured Lateral Noise Levels: Measured lateral noise levels may not be the same at symmetrical noise measurement points even when the data are adjusted for airplane position (for flight directly over the extended runway centerline). This non-symmetrical nature of measured sideline noise is primarily attributable to the direction of engine or propeller rotation. Because of inlet shielding, turbojet powered airplanes may exhibit 1-2 dB differences in lateral noise levels. Turbo-propeller powered airplanes can exhibit differences in lateral noise levels in excess of 6 dB. Due to their inherent lateral noise asymmetry, for propeller-driven airplanes, section B36.4 requires that simultaneous measurements be made at each and every test noise measurement point at its

symmetrical position on the opposite side of the runway.

c. Procedures

None

259. Section A36.9.4 Integrated method of adjustment.

260. Section A36.9.4.1 General.

As described in this section, the integrated adjustment method consists of recomputing under reference conditions points on the PNLT time history corresponding to measured points obtained during the tests, and computing EPNL directly for the new time history obtained in this way. The main principles are described in sections A36.9.4.2 through A36.9.4.4.1.

a. Explanation

This section specifies the methodology of the integrated method used for adjusting measured noise data to reference conditions

b. Supplemental Information

(1) Section 6.6 of the Appended ICAO TM provides details of an approved integrated adjustment method when the airplane is operated at stabilized flight path and thrust (power) conditions during the noise measurement period.

c. Procedures

None

261. Section A36.9.4.2 PNLT computations.

(a) The portions of the test flight path and the reference flight path described in paragraph (a)(1) and (2), and illustrated in Figure A36-10, include the noise time history that is relevant to the calculation of flyover and approach EPNL. In figure A36-10:

(1) XY represents the portion of the measured flight path that includes the noise time history relevant to the calculation of flyover and approach EPNL; X_rY_r represents the corresponding reference flight path.

(2) The points Q_0, Q_1, Q_n represent airplane positions on the measured flight path at time t_0, t_1 and t_n respectively. Point Q_1 is the point at which the noise was emitted and observed as one-third octave values $SPL(i)_1$ at the noise measuring station K at time t_1. Point Q_{r1} represents the corresponding position on the reference flight path for noise observed as $SPL(i)_{r1}$ at the reference measuring station K_r at time t_{r1}. Q_1K and $Q_{r1}K_r$ are respectively the measured and reference noise propagation paths, which in each case form the angle θ_1 with their respective flight paths. Q_{r0} and Q_{rn} are similarly the points on the reference flight path corresponding to Q0 and Qn on the measured flight path. Q_0 and Q_n are chosen so that between Q_{r0} and Q_{rn} all values of $PNLT_r$ (computed as described in paragraphs A36.9.4.2.2 and A36.9.4.2.3) within 10 dB of the peak value are included.

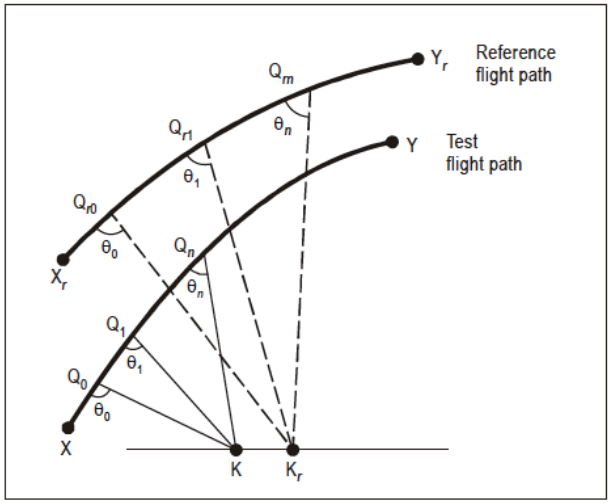


Figure A36-10. Correspondence between measured and reference flight paths for application of correction integrated methods

(b) The portions of the test flight path and the reference flight path described in paragraph (b)(1) and (2), and illustrated in Figure A36-11(a) and (b), include the noise time history that is relevant to the calculation of lateral EPNL.

(1) In figure A36-11(a) XY represents the portion of the measured flight path that includes the noise time history that is relevant to the calculation of lateral EPNL; in figure A36-11(b), X_rY_r represents the

corresponding portion of the reference flight path.

(2) The points Q_0, Q_1, Q_n represent airplane positions on the measured flight path at time t_0, t_1 and t_n respectively. Point Q_1 is the point at which the noise was emitted and observed as one-third octave values $SPL(i)_1$ at the noise measuring station K at time t_1. The point Q_{r1} represents the corresponding position on the reference flight path for noise observed as $SPL(i)_{r1}$ at the measuring station K_r at time t_{r1}. Q_1K and $Q_{r1}K_r$ are respectively the measured and reference noise propagation paths. Q_{r0} and Q_{rn} are similarly the points on the reference flight path corresponding to Q_0 and Q_n on the measured flight path. Q_0 and Q_n are chosen to that between Q_{r0} and Q_{rn} all values of $PNLT_r$ (computed as described in paragraphs A36.9.4.2.2 and A36.9.4.2.3) within 10 dB of the peak value are included. In this case K_r is only specified as being on a particular lateral line. The position of K_r and Q_{r1} are determined from the following requirements:

(i) Q_1K and $Q_{r1}K_r$ form the same angle θ_1 with their respective flight paths; and

(ii) The differences between the angles ψ_1 and ψ_{r1} must be minimized using a method, approved by the CAAC. The differences between the angles are minimized since, for geometrical reasons, it is generally not possible to choose K_r so that the condition described in paragraph A36.9.4.2(b)(2)(i) is met while at the same time keeping ψ_1 and ψ_{r1} equal.

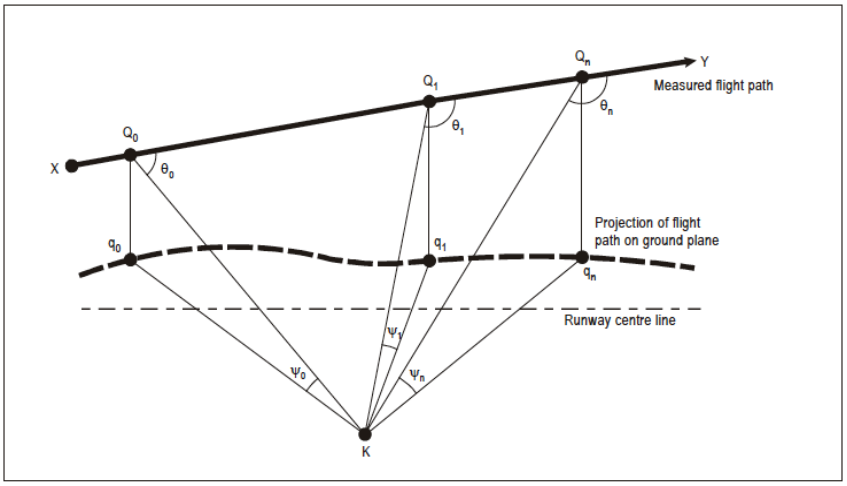


Figure A36-11(a). Measured flight path

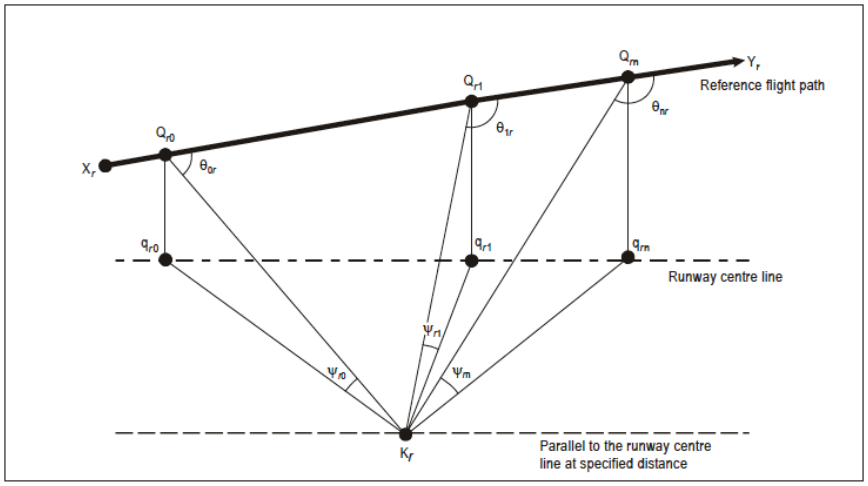


Figure A36-11(b). Reference flight path

Note: For the lateral noise measurement, sound propagation is affected not only by "inverse square" and atmospheric attenuation, but also by ground absorption and reflection effects which depend mainly on the angle ψ.

a. Explanation

This section specifies the portions of the test and reference flight paths that are significant for computation of EPNLr (i.e., encompassing the 10 dB-down points), the symbols for airplane positions at different time intervals, and noise angles (which are equated between respective test and reference flight paths).

b. Supplemental Information

(1) Emission Angles: For the integrated method, each one-half second noise data record will define a separate noise emission angle. This angle will then define the location of each data record along the reference flight path. The distance between consecutive data records along the reference flight path divided by the reference path speed provides the time interval between reference data records. The reference duration of each of these data records can be determined by obtaining the average of the two intervals between the adjacent data records. (This may be different than 0.5 seconds). See section 6.6 of the Appended ICAO TM for discussion of time interval computations using the integrated method.

c. Procedures

(1) Elevation Angles: If the integrated method is used for lateral noise

measurements and it is not possible to equate the elevation angle for the test flight path to that for the reference flight path after equating test and reference noise emission angles, then the elevation angle differences should be minimized using a method approved by the CAAC.

262. Section A36.9.4.2.1

In paragraphs A36.9.4.2(a)(2) and (b)(2) the time t_{r1} is later (for $Q_{r1}K_r > Q_1K$) than t_1 by two separate amounts:

(1) The time taken for the airplane to travel the distance $Q_{r1}Q_{r0}$ at a speed V_r less the time taken for it to travel Q_1Q_0 at V;

(2) The time taken for sound to travel the distance $Q_{r1}K_r - Q_1K$.

Note: For the flight paths described in paragraphs A36.9.4.2(a) and (b), the use of thrust or power cut-back will result in test and reference flight paths at full thrust or power and at cutback thrust or power. Where the transient region between these thrust or power levels affects the final result, an interpolation must be made between them by an approved method such as that given in the current advisory circular for this part.

a. Explanation

This section specifies the factors that relate to the difference in the emission times between the reference flight path and the test flight path using the integrated method.

b. Supplementary Information

(1) See section 6.6 of the Appended ICAO TM for discussion of time interval computations using the integrated method.

c. Procedures

None

263. Section A36.9.4.2.2

The measured values of $SPL(i)_1$ must be adjusted to the reference values $SPL(i)_{r1}$ to account for the differences between measured and reference noise

path lengths and between measured and reference atmospheric conditions, using the methods of section A36.9.3.2.1 of this appendix. A corresponding value of PNL_{r1} must be computed according to the method in section A36.4.2. Values of PNL_r must be computed for times t_0 through t_n.

264. Section A36.9.4.2.3

For each value of PNL_{r1}, a tone correction factor C_1 must be determined by analyzing the reference values $SPL(i)_r$ using the methods of section A36.4.3 of this appendix, and added to PNL_{r1} to yield $PNLT_{r1}$. Using the process described in this paragraph, values of $PNLT_r$ must be computed for times t_0 through t_n.

265. Section A36.9.4.3 Duration correction.

266. Section A36.9.4.3.1

The values of $PNLT_r$ corresponding to those of PNLT at each one-half second interval must be plotted against time ($PNLT_{r1}$ at time t_{r1}). The duration correction must then be determined using the method of section A36.4.5.1 of this appendix, to yield $EPNL_r$.

a. Explanation

This section specifies the method of determining the duration correction needed to obtain $EPNL_r$ when using the "integrated" method.

b. Supplementary Information

(1) See section 6.6.7 of the appended ICAO TM for discussion of adjusted EPNL computations when using the "integrated" method.

c. Procedures

(1) Application of Band Sharing Adjustment for "Integrated" Method: See the Supplementary Information and Procedures presented in A36.4.4.2. This adjustment must be applied to the maximum $EPNL_r$ before calculation of the Duration Correction and $EPNL_r$.

(2) Application of High-Altitude Site Jet Noise Adjustment for "Integrated" Method: When the Equivalent Procedure for use of high-altitude test sites (Elevation > 1200 feet MSL) is employed, and the "Integrated" adjustment method is used to determine EPNLr values, the adjustments must be applied either to the measured one-third octave band sound pressure levels, SPL(i,k), or to the adjusted one-third-octave-band sound pressure levels, $SPL(i,k)_r$, throughout the entire 10 dB-down period. See Appendix 6 of the appended ICAO TM, for information on the equivalent procedure for testing at high-altitude sites.

267. Section A36.9.4.4 Source noise adjustment.

268. Section A36.9.4.4.1

A source noise adjustment, Δ_3, must be determined using the methods of section A36.9.3.4 of this appendix.

269. Section A36.9.5 Flight Path Identification Positions.

Position	*Description*
A	***Start of Takeoff roll.***
B	***Lift-off.***
C	***Start of first constant climb.***
D	***Start of thrust reduction.***
E	***Start of second constant climb.***
F	***End of noise certification Takeoff flight path.***
G	***Start of noise certification Approach flight path.***
H	***Position on Approach path directly above noise measuring station.***
I	***Start of level-off.***
J	***Touchdown.***
K	***Noise measurement point.***
K_r	***Reference measurement point.***
K_1	***Flyover noise measurement point.***
K_2	***Lateral noise measurement point.***
K_3	***Approach noise measurement point.***

M	***End of noise certification Takeoff flight track.***
O	***Threshold of Approach end of runway.***
P	***Start of noise certification Approach flight track.***
Q	***Position on measured Takeoff flight path corresponding to apparent PNLTM at station K See section A36.9.3.2.***
Q_r	***Position on corrected Takeoff flight path corresponding to PNLTM at station K. See section A36.9.3.2.***
V	***Airplane test speed.***
V_r	***Airplane reference speed.***

270. Section A36.9.6 Flight Path Distances.

Distance	*Unit*	*Meaning*
AB	***Feet (meters)***	***Length of takeoff roll. The distance along the runway between the start of takeoff roll and lift off.***
AK	***Feet (meters)***	***Takeoff measurement distance. The distance from the start of roll to the takeoff noise measurement station along the extended center line of the runway.***
AM	***Feet (meters)***	***Takeoff flight track distance. The distance from the start of roll to the takeoff flight track position along the extended center line of the runway after which the position of the airplane need no longer be recorded.***
QK	***Feet (meters)***	***Measured noise path. The distance from the measured airplane position Q to station K.***
Q_rK_r	***Feet (meters)***	***Reference noise path. The distance from the reference airplane position Q_r to station K_r.***
K_3H	***Feet (meters)***	***Airplane approach height. The height of the airplane above the approach measuring station.***
OK_3	***Feet (meters)***	***Approach measurement distance. The distance from the runway threshold to the approach measurement station along the extended center line of the runway.***
OP	***Feet (meters)***	***Approach flight track distance. The distance from the runway threshold to the approach flight track position along the extended center line of the runway after which the position of***

		the airplane need no longer be recorded.

a. Explanation

This section specifies the flight path identification positions, their symbols, and associated units.

b. Supplemental Information

None

c. Procedures

None

271. - 289--RESERVED

XIII. APPENDIX B — NOISE LEVELS FOR TRANSPORT CATEGORY AND JET AIRPLANES UNDER § 36.103

290. Appendix B--Noise Levels for Transport Category and Jet Airplanes Under § 36.103

Sec.

B36.1 Noise measurement and evaluation.

B36.2 Noise evaluation metric.

B36.3 Reference noise measurement points.

B36.4 Test noise measurement points.

B36.5 Maximum noise levels.

B36.6 Trade-offs.

B36.7 Noise certification reference procedures and conditions.

B36.8 Noise certification test procedures.

a. Explanation

Appendix B addresses the noise measurement and evaluation requirements, test and reference

procedures, and maximum noise levels (noise limits) that FAA uses as the basis for assessment of compliance of

subsonic transport category large airplanes and jet airplanes with part 36.

b. Supplemental Information

None

c. Procedures

None

291. Section B36.1 Noise Measurement and Evaluation.

(a) The procedures of Appendix A of this part, or approved equivalent

procedures, must be used to determine noise levels of an airplane. These noise levels must be used to show compliance with the requirements of this appendix.

(b) For Stage 4 airplanes, an acceptable alternative for noise measurement and evaluation is Appendix 2 to the International Civil Aviation Organization (ICAO) Annex 16, Environmental Protection, Volume I, Aircraft Noise, Third Edition, July 1993, Amendment 7, effective March 21, 2002.

a. Explanation

This section specifies that an applicant's noise measurement and evaluation methods must conform to those of Appendix A or to CAAC approved equivalent procedures for compliance with the maximum noise level (noise limit) requirements of part 36 section B36.5.

b. Supplemental Information

None

c. Procedure

None

292. Section B36.2 Noise Evaluation Metric.

The noise evaluation metric is the effective perceived noise level expressed in EPNdB, as calculated using the procedures of appendix A of this part.

a. Explanation

This section specifies that the noise evaluation metric to be used in showing compliance with the noise limits is the Effective Perceived Noise Level (in units of EPNdB). See section A36.4 for a description of EPNL and the methodology for its calculation.

b. Supplemental Information

None

c. Procedures

None

293. Section B36.3 Reference Noise Measurement Points.

When tested using the procedures of this part, except as provided in section B36.6, an airplane may not exceed the noise levels specified in section B36.5 at the following points on level terrain:

(a) Lateral full-power reference noise measurement point:

(1) For jet airplanes:

The point on a line parallel to and 450 m (1,476 ft) from the runway centerline, or extended centerline, where the noise level after lift-off is at a maximum during takeoff. For the purpose of showing compliance with Stage 1 or Stage 2 noise limits for an airplane powered by more than three jet engines, the distance from the runway centerline must be 648 m (0.35 nautical miles). For jet airplanes, when approved by the CAAC, the maximum lateral noise at takeoff thrust may be assumed to occur at the point (or its approved equivalent) along the extended centerline of the runway where the airplane reaches 300 m (985 ft) altitude above ground level. A height of 435 m (1427 ft) may be assumed for Stage 1 or Stage 2 four engine airplanes. The altitude of the airplane as it passes the noise measurement points must be within +100 to -50 m (+328 to -164 ft) of the target altitude. For airplanes powered by other than jet engines, the altitude for maximum lateral noise must be determined experimentally.

(2) For propeller-driven airplanes: The point on the extended centerline of the runway above which the airplane, at full takeoff power, reaches a height of 650 m (2,133 ft). For tests conducted before April 15, 2007, an applicant may use the measurement point specified in section B36.3(a)(1) as an alternative.

(b) Flyover reference noise measurement point: The point on the extended centerline of the runway that is 6,500 m (21,325 ft) from the start of the takeoff roll;

(c) Approach reference noise measurement point: The point on the extended centerline of the runway that is 2,000 m (6,562 ft) from the runway threshold. On level ground, this corresponds to a position that is 120 m (394 ft) vertically below the 3° descent path, which originates at a point on the runway 300 m (984 ft) beyond the threshold.

a. Explanation

This section specifies the locations of reference noise measurement points for flyover, lateral and approach noise measurements.

b. Supplemental Information

None

c. Procedures

None

294. Section B36.4 Test noise measurement points.

(a) If the test noise measurement points are not located at the reference noise measurement points, any corrections for the difference in position are to be made using the same adjustment procedures as for the differences between test and reference flight paths.

(b) The applicant must use a sufficient number of lateral test noise measurement points to demonstrate to the CAAC that the maximum noise level on the appropriate lateral line has been determined. For jet airplanes, simultaneous measurements must be made at one test noise measurement point at its symmetrical point on the other side of the runway. Propeller-driven airplanes have an inherent asymmetry in lateral noise. Therefore, simultaneous measurements must be made at each and every test noise measurement point at its symmetrical position on the opposite side of the runway. The measurement points are considered to be symmetrical if they are longitudinally within ±10 m (±33 ft) of each other.

a. Explanation

This section specifies CAAC requirements when test noise measurement points are not located at reference noise measurement positions and the criteria for selection of lateral noise measurement points for jet airplanes and propeller-driven airplanes.

b. Supplemental Information

(1) Measured Lateral Noise Levels: Measured lateral noise levels may not be the same at symmetrical noise measurement points even when the data are adjusted for airplane position (for flight directly over the extended runway centerline). The direction of engine or propeller rotation may be an important factor in the non-symmetrical nature of measured lateral noise. Inlet shielding may cause turbojet-powered airplanes to exhibit 1-2 dB differences in lateral

noise levels. Propeller-driven airplanes may exhibit differences in lateral noise levels in excess of 6 dB. Due to their inherent lateral noise asymmetry, for propeller-driven airplanes, section B36.4 requires that simultaneous measurements be made at each and every test noise measurement point at its symmetrical position on the opposite side of the runway.

(2) Maximum Lateral Noise Levels: An applicant may conduct noise measurements at several altitudes over symmetrically located noise measurement points in accordance with an CAAC approved noise compliance demonstration plan to determine the maximum lateral noise levels. Typically, a 2nd order curve fit through the adjusted noise levels as a function of airplane altitude is sufficient to determine the maximum average lateral noise level and the altitude at which it occurred. Valid noise certification test data cannot be discarded.

(3) Maximum Lateral Noise Levels (Alternative Procedure): Section B36.3(a)(1) contains an alternative procedure whereby the maximum lateral noise level may be assumed to occur at the point (or its approved equivalent) along the extended centerline of the runway where the airplane reaches 985 feet (1427 feet for Stage 1 or Stage 2 four engine airplanes) altitude above ground level. Section 2.1.3.2 of the appended ICAO Environmental Technical Manual describes a similar equivalent procedure. However, unlike the ICAO TM equivalent procedure, use of the alternative procedure contained in section B36.3(a)(1) is not restricted to engines with bypass ratios of more than 2. Prior approval from the CAAC is required to use this alternative procedure.

c. Procedure

(1) Applicant's Responsibility: An applicant must include proposed equivalent procedures for lateral noise measurements in a noise compliance demonstration plan for CAAC review and approval.

295. Section B36.5 Maximum Noise Levels

Except as provided in section B36.6 of this appendix, maximum noise levels, when determined in accordance with the noise evaluation methods of appendix A of this part, may not exceed the following:

(a) For acoustical changes to Stage 1 airplanes, regardless of the number of engines, the noise levels prescribed under §36.7(c) of this part.

(b) For any Stage 2 airplane regardless of the number of engines:

(1) Flyover: 108 EPNdB for maximum weight of 272,000 kg (600,000 pounds) or more; for each halving of maximum weight (from 272,000 kg (600,000 pounds)), reduce the limit by 5 EPNdB; the limit is 93 EPNdB for a maximum weight of 34,000 kg (75,000 pounds) or less.

(2) Lateral and approach: 108 EPNdB for maximum weight of 272,000 kg (600,000 pounds) or more; for each halving of maximum weight (from 272,000 kg (600,000 pounds)), reduce the limit by 2 EPNdB; the limit is 102 EPNdB for a maximum weight of 34,000 kg (75,000 pounds) or less.

(c) For any Stage 3 airplane:

(1) Flyover.

(i) For airplanes with more than 3 engines: 106 EPNdB for maximum weight of 385,000 kg (850,000 pounds) or more; for each halving of maximum weight (from 385,000 kg (850,000 pounds)), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 20,200 kg (44,673 pounds) or less;

(ii) For airplanes with 3 engines: 104 EPNdB for maximum weight of 385,000 kg (850,000 pounds) or more; for each halving of maximum weight (from 385,000 kg (850,000 pounds)), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 28,600 kg (63,177 pounds) or less; and

(iii) For airplanes with fewer than 3 engines: 101 EPNdB for maximum weight of 385,000 kg (850,000 pounds) or more; for each halving of maximum weight (from 385,000 kg (850,000 pounds)), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 48,100 kg (106,250 pounds) or less.

(2) Lateral, regardless of the number of engines: 103 EPNdB for maximum weight of 400,000 kg (882,000 pounds) or more; for each halving of maximum weight (from 400,000 kg (882,000 pounds)), reduce the limit by 2.56 EPNdB; the limit is 94 EPNdB for a maximum weight of 35,000 kg (77,200 pounds) or less.

(3) Approach, regardless of the number of engines: 105 EPNdB for maximum weight of 280,000 kg (617,300 pounds) or more; for each halving of maximum weight (from 280,000 kg (617,300 pounds)), reduce the limit by 2.33 EPNdB; the limit is 98 EPNdB for a maximum weight of 35,000 kg (77,200 pounds) or less.

(d) For any Stage 4 airplane, the flyover, lateral, and approach maximum noise levels are prescribed in Chapter 4, Paragraph 4.4, Maximum Noise Levels, and Chapter 3, Paragraph 3.4, Maximum Noise Levels, of the International Civil Aviation Organization (ICAO) Annex 16, Environmental Protection, Volume I, Aircraft Noise, Third Edition, July 1993, Amendment 7, effective March 21, 2002.

a. Explanation

This section specifies maximum noise levels (noise limits) at flyover, lateral and approach reference noise measurement points as a function of airplane maximum takeoff gross weight. For the flyover noise measurement point, the maximum noise levels (noise limits) are specified for the number of airplane engines as well as maximum weight.

b. Supplemental Information

(1) Stage Definitions: Definitions of Stage 1, Stage 2, Stage 3and Stage 4 airplanes are given in section 36.1 of Subpart A.

(2) Acoustical Change: Requirements for FAA approval of Stage 1, Stage 2 and Stage 3 airplane Acoustical Changes, applied for under, Part 21.93(b) are specified in section 36.7 of Subpart A.

c. Procedures

(1) Maximum Noise Levels (Noise Limits): Flyover, lateral and approach maximum noise levels (noise limits) for Stage 2 and Stage 3 airplanes are given below.

Stage 2 airplanes:

M = Maximum take-off mass in 1 000 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

Stage 3 airplanes:

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)	101		89.03 + 7.75 log M					108	

All aeroplanes					
Flyover noise	2 engines	93	70.62 + 13.29 log M		104
levels	3 engines	93	67.56 + 16.61 log M	73.62 + 13.29 log M	107
(EPNdB)	4 engines	93	67.56 + 16.61 log M	74.62 + 13.29 log M	108

If using Imperial units, these maximum noise levels (noise limits) are given below.

Stage	No. of Engines	Maximum Weight (MTOGW), pounds	Flyover Limit, dB	Lateral Limit, dB	Approach Limit, dB
2	Any number	75,000 and less	93.0	102.0	102.0
2	Any number	between 75,000 and 600,000	See Eqn. A	See Eqn. B	See Eqn. B
2	Any number	600,000 and more	108.0	108.0	108.0
3	Fewer than 3	106,250 and less	89.0		
3	Fewer than 3	between 106,250 and 850,000	See Eqn. C		
3	Fewer than 3	850,000 and more	101		
3	Three	63,177 and less	89.0		
3	Three	between 63,177 and 850,000	See Eqn. C		
3	Three	850,000 and more	104.0		
3	More than 3	44,673 and less	89.0		
3	More than 3	between 44,673 and 850,000	See Eqn. C		
3	More than 3	850,000 and more	106.0		
3	Any number	77,200 and less		94.0	
3	Any number	between 77,200 and 882,000		See Eqn. D	
3	Any number	882,000 and more		103.0	
3	Any number	77,200 and less			98.0
3	Any number	between 77,200 and 617,300			See Eqn. E
3	Any number	617,300 and more			105.0

Eqn. A: Limit Flyover EPNL = 93.0 + 5.0 [(log (Maximum weight /75,000))÷(log 2.0)]

Eqn. B: Limit Approach EPNL = 102.0 + 2.0 [(log (Maximum weight /75,000))÷(log 2.0)]

Eqn. C: Limit Flyover EPNL = 89.0 + 4.0 [(log (Maximum weight / 'K'))÷(log 2.0)], where:

Number of Engines	Eqn. C， 'K' value
Fewer than 3	106,250
Three	63,177
More than 3	44,673

Eqn. D: Limit Lateral EPNL = 94.0 + 2.56 [(log (Maximum weight /77,200))÷(log 2.0)]

Eqn. E: Limit Approach EPNL = 98.0 + 2.33 [(log (Maximum weight /77,200))÷(log 2.0)]

Note: Maximum weights are considered to be the certificated maximum takeoff gross weight (MTOGW) at brake release for Flyover, Lateral and Approach noise measurement points.

296. Section B36.6 Trade-Offs.

Except when prohibited by sections 36.7(c)(1) and 36.7(d)(1)(ii), if the maximum noise levels are exceeded at any one or two measurement points, the following conditions must be met:

(a) The sum of the exceedance(s) may not be greater than 3 EPNdB;

(b) Any exceedance at any single point may not be greater than 2 EPNdB, and

(c) Any exceedance(s) must be offset by a corresponding amount at another point or points.

a. Explanation

This section specifies the noise level tradeoffs an applicant may use in demonstrating Stage 2 and Stage 3 compliance with part 36.

b. Supplemental Information

(1) Tradeoff Provisions: Tradeoffs are permitted in determining compliance with the Stage 2 and Stage 3 maximum noise level (noise limit) requirements of part 36 because of the cumulative aspects of noise exposure. Limited "exceedances" to the flyover, lateral and approach noise limits are acceptable when compensated by noise reductions at the other noise measurement points,

(2) Stage 1 Airplanes: CAAC does not permit an applicant to use tradeoffs to increase Stage 1 airplane flyover, lateral or approach noise levels.

c. Procedures

(1) Use of Tradeoffs: The following example demonstrates how tradeoffs are used:

Airplane Classification = Stage 3

Number of Engines = 3

Airplane MTOGW = 300,000 pounds

Stage 3 Noise Limits:

Flyover = 97.99 EPNdB

Lateral = 99.01 EPNdB

Approach = 102.56 EPNdB

Demonstrated Noise Levels:

Flyover = 99.83 EPNdB

Lateral = 98.19 EPNdB

Approach = 101.54 EPNdB

Total Exceedance:

Flyover = +1.84 EPNdB

Total Reduction:

Lateral + Approach = (-0.82) + (-1.02) = 0 EPNdB

This airplane complies with part 36 maximum noise level (noise limit) requirements for a Stage 3 airplane through the use of tradeoffs. Note that, as illustrated by this example, the tradeoff analysis is typically conducted to two decimal places.

297. Section B36.7 Noise Certification Reference Procedures and Conditions.

298. Section B36.7(a) General conditions:

(1) All reference procedures must meet the requirements of section 36.3 of this part.

(2) Calculations of airplane performance and flight path must be made using the reference procedures and must be approved by the CAAC.

(3) Applicants must use the takeoff and approach reference procedures prescribed in paragraphs (b) and (c) of this section.

(4) [Reserved]

(5) The reference procedures must be determined for the following reference conditions. The reference atmosphere is homogeneous in terms of

temperature and relative humidity when used for the calculation of atmospheric absorption coefficients.

(i) Sea level atmospheric pressure of 2,116 pounds per square foot (psf) (1013.25 hPa);

(ii) Ambient sea-level air temperature of 77 °F (25 °C, i.e. , ISA+10 °C);

(iii) Relative humidity of 70 per cent;

(iv) Zero wind.

(v) In defining the reference takeoff flight path(s) for the takeoff and lateral noise measurements, the runway gradient is zero.

a. Explanation

This section specifies the airworthiness criteria, reference atmospheric conditions and runway gradient to be used for calculation of takeoff and approach reference procedures

b. Supplemental Information

(1) Reference Conditions and Procedures: Uniform reference conditions and procedures are required in order to have a common basis of comparison of the values of $EPNL_r$ which are obtained for airplanes tested under a range of conditions, with the part 36 noise limits.

(2) Equivalent Procedures: The FAA does not permit equivalent procedures for certification reference procedures (e.g., 3° glide path).

c. Procedures

None

299. Section B36.7(b) Takeoff reference procedure:

The takeoff reference flight path is to be calculated using the following:

300. Section B36.7(b)(1)

(1) Average engine takeoff thrust or power must be used from the start of takeoff to the point where at least the following height above runway level is

reached. The takeoff thrust/power used must be the maximum available for normal operations given in the performance section of the airplane flight manual under the reference atmospheric conditions given in section B36.7(a)(5).

(i) For Stage 1 airplanes and for Stage 2 airplanes that do not have jet engines with a bypass ratio of 2 or more, the following apply:

(A): For airplanes with more than three jet engines—214 m (700 ft).

(B): For all other airplanes—305 m (1,000 ft).

(ii) For Stage 2 airplanes that have jet engines with a bypass ratio of 2 or more and for Stage 3 airplanes, the following apply:

(A): For airplanes with more than three engines—210 m (689 ft).

(B): For airplanes with three engines—260 m (853 ft).

(C): For airplanes with fewer than three engines—300 m (984 ft).

a. Explanation

This section specifies the reference engine thrust (power) and minimum altitude for thrust (power) reduction that an applicant must use to calculate reference flight paths for Stage 1, Stage 2, and Stage 3 airplanes.

b. Supplemental Information

(1) Takeoff Without Thrust (Power) Reduction: Average engine takeoff thrust (power) must be used throughout the takeoff flight path without reducing thrust (power). Some applicants find that it is simpler to test with takeoff thrust (power) only - when values of $EPNL_r$ do not exceed part 36 maximum noise levels (noise limits). This is especially true for turboprop powered transport category airplanes. On or after August 7, 2002, lateral noise levels must be determined using a flight path for which takeoff thrust (power) is used throughout, i.e., thrust (power) reduction will not be permitted.

c. Procedures

(1) Reference Takeoff Procedure with Thrust (Power) Reduction: For calculation of a takeoff reference procedure that includes a thrust (power) reduction, average engine takeoff thrust (power) is used at the point of brake release and maintained as the airplane proceeds along the runway, rotates and lifts off according to normal airworthiness requirements. The airplane then retracts the landing gear, and establishes a first segment climb gradient prior to

reaching an appropriate altitude for thrust (power) reduction. Beyond this altitude the second segment climb gradient is established at reduced thrust (power) and maintained throughout the 10 dBdown period. Aerodynamic control surfaces (including flap position) are maintained constant throughout this procedure. See section 2.2.1 of the appended ICAO TM.

(2) Thrust (Power) Reduction Altitude: The thrust (power) reduction altitude proposed by the applicant must be equal to or greater than the minimum altitudes specified in section B36.7(b)(1).

Note: CAAC policy requires an applicant to take into account the following two airplane operational factors in determining an altitude for thrust (power) reduction within a reference flight path (Also see section 2.2.1 of the appended ICAO TM):

(i) A one-second delay to account for pilot recognition and response prior to movement of the throttles to the reduced thrust (power) position.

(ii) An average period of time for an airplane's engines to spool-down from takeoff thrust (power) to reduced thrust (power).

(3) Spool-Down Tests: CAAC-witnessed flight tests of an airplane to be used for noise certification measurements are required to obtain at least six acceptable spool-down times of each engine from average engine takeoff thrust (power) to reduced thrust (power) at the lowest maximum weight to be certified. These tests should be conducted at altitudes approximately 3000 feet AGL and at airspeeds comparable to reference airspeeds as defined in section B36.7(b)(4). An applicant's proposal for these tests must be included in a noise compliance demonstration plan.

301. Section B36.7(b)(2)

(2) Upon reaching the height specified in paragraph (b)(1) of this section, airplane thrust or power must not be reduced below that required to maintain either of the following, whichever is greater:

(i) A climb gradient of 4 per cent; or

(ii) In the case of multi-engine airplanes, level flight with one engine inoperative.

a. Explanation

This section specifies the minimum thrust (power) that is required after an

airplane has reached a minimum altitude for thrust reduction as required by section B36.7(b)(1).

b. Supplemental Information

(1) Lapse Rate Effect on Engine Thrust (Power): The climb gradient after reducing thrust may decrease because, for a constant thrust (power) setting, as the airplane altitude increases there is a decrease in engine thrust (power) due to lapse rate.

(2) Single Engine Airplane Reduced Thrust (Power) Requirements: For single engine airplanes, the minimum reduced thrust (power) required is that which is necessary to maintain a 4% climb gradient.

c. Procedures

None

302. Section B36.7(b)(3)

For the purpose of determining the lateral noise level, the reference flight path must be calculated using full takeoff power throughout the test run without a reduction in thrust or power. For tests conducted before April 15, 2007, a single reference flight path that includes thrust cutback in accordance with paragraph (b)(2) of this section, is an acceptable alternative in determining the lateral noise level.

a. Explanation

This section specifies criteria for an applicant to calculate lateral reference flight paths.

b. Supplemental Information

None

c. Procedures

None

303. Section B36.7(b)(4)

The takeoff reference speed is the all-engine operating takeoff climb speed selected by the applicant for use in normal operation; this speed must be at least V_2 + 19 km/h (V_2 + 10 knots) but may not be greater than V_2 + 37 km/h

(V_2 + 20knots). This speed must be attained as soon as practicable after lift-off and be maintained throughout the takeoff noise certification test. For all airplanes, noise values measured at the test day speeds must be corrected to the acoustic day reference speed.

a. Explanation

This section specifies airspeed criteria that an applicant must use to calculate the takeoff reference flight path of subsonic transport category large airplanes, jet airplanes and Concorde airplanes.

b. Supplemental Information

None

c. Procedures

(1) V_2 Takeoff Airspeed: Criteria for determining V_2 takeoff airspeeds are specified in section 25.107 “Takeoff Speeds”.

(2) Applicant's Responsibility: The applicant is responsible for determination of appropriate takeoff reference airspeeds for airplane maximum weights.

304. Section B36.7(b)(5)

The takeoff configuration selected by the applicant must be maintained constantly throughout the takeoff reference procedure, except that the landing gear may be retracted. Configuration means the center of gravity position, and the status of the airplane systems that can affect airplane performance or noise. Examples include, the position of lift augmentation devices, whether the APU is operating, and whether air bleeds and engine power take-offs are operating;

a. Explanation

None

b. Supplemental Information

(1) Applicant’s Options for Selection of Takeoff Configuration: The noise certification takeoff configuration that is selected by the applicant must be within the airworthiness approved configurations, as recorded in the AFM. Example: If the applicant has certificated flap settings 2, 5 and 10 and those

settings are identified in the AFM, then they are valid options for noise measurements during takeoff. Flap setting 0 is not a valid option in this example. Noise certification compliance for a configuration that is different from the tested configuration may require re-testing or an equivalency finding by the CAAC.

c. Procedure

(1) Applicant's Responsibility: An applicant is responsible for demonstrating that an appropriate airplane takeoff configuration is selected and maintained for the calculation of the reference takeoff procedure.

305. Section B36.7(b)(6)

The weight of the airplane at the brake release must be the maximum takeoff weight at which the noise certification is requested, which may result in an operating limitation as specified in §36.1581(d); and

a. Explanation

This section specifies criteria for defining a reference maximum takeoff weight of an airplane.

b. Supplemental Information

(1) Part 36 section 36.1581 Requirements: An airplane reference maximum takeoff weight for noise certification which is less than the maximum weight established under applicable airworthiness requirements must be furnished as an operating limitation in the limitations section of the airplane flight manual.

c. Procedure

(1) Applicant’s Responsibility: An applicant must define and obtain CAAC approval of an airplane maximum takeoff weight to calculate reference EPNL values.

306. Section B36.7(b)(7)

The average engine is defined as the average of all the certification compliant engines used during the airplane flight tests, up to and during certification, when operating within the limitations and according to the procedures given in the Flight Manual. This will determine the relationship of

thrust/power to control parameters (e.g., N_1 or EPR). Noise measurements made during certification tests must be corrected using this relationship.

a. Explanation

This section specifies criteria for defining an airplane's average engine thrust (power) characteristics.

b. Supplemental Information

None

c. Procedure

(1) Applicant's Responsibility: An applicant must define and obtain CAAC approval of an airplane's average engine thrust (power) characteristics to calculate reference EPNL values.

307. Section B36.7(c) Approach reference procedure:

The approach reference flight path must be calculated using the following:

308. Section B36.7(c)(1)

The airplane is stabilized and following a 3° glide path;

a. Explanation

This section specifies the reference conditions that an applicant must use in calculating an approach reference flight path.

b. Supplemental Information

None

c. Procedures

None

309. Section B36.7(c)(2)

For subsonic airplanes, a steady approach speed of V_{ref} + 19 km/h (V_{ref} + 10 knots) with thrust and power stabilized must be established and maintained

over the approach measuring point. V_{ref} is the reference landing speed, which is defined as the speed of the airplane, 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. This speed must be established and maintained over the approach measuring point.

a. Explanation

This section specifies the criteria that an applicant must use to determine reference approach airspeeds for subsonic transport category large airplanes and jet airplanes.

b. Supplemental Information

None

c. Procedures

None

310. Section B36.7(c)(3)

The constant approach configuration used in the airworthiness certification tests, but with the landing gear down, must be maintained throughout the approach reference procedure;

a. Explanation

None

b. Supplemental Information

(1) Approach Airworthiness Certification: Under the airworthiness regulations, airplanes are frequently airworthiness-certificated for more than one approach configuration. Such configurations may include:

(i) Multiple approach/landing flap settings and landing weights;

(ii) In-flight operable APU;

(iii) Environmental Control system operational conditions;

(iv) Engine bleed valve operational conditions.

The configuration that is most critical from a noise standpoint is the configuration that must be used for determination of reference approach EPNL values.

(2) Emergency Approach Configuration: Some airplanes are equipped with emergency in-flight operable equipment such as emergency air-turbine driven generators and emergency air-turbine driven hydraulic pumps. Emergency equipment operation is not a part of normal approach airworthiness approved configurations that require part 36 compliance.

(3) Restricted Configurations: On some airplanes, flap settings may be limited in order to comply with part 36 maximum noise levels (See section B36.5). For Stage 3 airplanes that require a flap limitation in order to comply with part 36, the installation of soft-guards and incorporation of appropriate AFM limitations are required. In addition, placards may be installed to provide appropriate information to the flight crew. Soft-guards make it obvious that limited flap settings are not to be used for normal operation, and would indicate any use of the unapproved settings by deformation of the soft-guard. For safety purposes, at the discretion of the flight crew, soft-guards allow use of noise restricted flap settings (that are airworthiness approved) for emergency conditions.

c. Procedures

(1) Applicant's Responsibility: An applicant is responsible for demonstrating that an appropriate airplane configuration is selected and maintained in determining a noise certification approach reference procedure. This includes evaluating which approach configuration is most critical for approach noise certification and identifying that critical configuration in a noise certification compliance demonstration plan.

311. Section B36.7(c)(4)

The weight of the airplane at touchdown must be the maximum landing weight permitted in the approach configuration defined in paragraph (c)(3) of this section at which noise certification is requested, except as provided in §36.1581(d) of this part; and

a. Explanation

This section specifies criteria for defining the reference maximum landing

weight of an airplane for noise certification.

b. Supplemental Information

None

c. Procedures

None

312. Section B36.7(c)(5)

The most critical configuration must be used; this configuration is defined as that which produces the highest noise level with normal deployment of aerodynamic control surfaces including lift and drag producing devices, at the weight at which certification is requested. This configuration includes all those items listed in section A36.5.2.5 of appendix A of this part that contribute to the noisiest continuous state at the maximum landing weight in normal operation.

a. Explanation

This section specifies criteria for defining the reference configuration of an airplane for noise certification.

b. Supplemental Information

None

c. Procedures

(1) Most Critical Approach Configuration: An applicant must determine the most noise-critical configuration at the airplane's maximum landing weight by evaluation of appropriate measured noise data and/or experience, or similarity with other airplane models. The results of this evaluation must include the effects of items listed in section A36.5.2.5.

Note: Example items warranting consideration are as follows:

(i) Flaps extended to the extreme approved landing flap position (e.g., 30º flaps) for turbojet airplanes and to the least approved landing flap position (e. g. 10° flaps) for turbo-propeller airplanes;

(ii) A/C (Environmental Control System) operating;

(iii) Landing gear extended;

(iv) Operation of an APU in-flight;

(v) Maximum approved landing gross weight, and

(vi) Inter-compressor bleed trimmed to maximum trim stop.

313. Section B36.8 Noise Certification Test Procedures

314. Section B36.8(a)

All test procedures must be approved by the CAAC.

a. Explanation

This section specifies a requirement for FAA approval of an applicant's proposals for airplane noise certification test procedures and noise measurements.

b. Supplemental Information

(1) Test Witnessing: An CAAC observer, or appropriately delegated designee, must witness airplane noise certification tests to ensure compliance with a CAAC approved noise certification compliance demonstration plan. (See paragraph 6-3(f) of reference 7 of this AC.)

c. Procedures

(1) Constant Configuration: A flight crew must not modify the takeoff or approach configurations during noise certification testing. They must set the airplane configuration (including engine thrust (power), flap position, APU and A/C operation, gear position, etc.) in sufficient time to stabilize all conditions prior to the initial 10 dB-down point, and maintain that configuration constantly until after the final 10 dB-down point.

Note: throttle movement during the noise measurement is not permitted, except as required by the pilot-in-command to ensure safety. If this occurs, the noise level certification test condition is invalid, and is to be repeated.

315. Section B36.8(b)

The test procedures and noise measurements must be conducted and processed in an approved manner to yield the noise evaluation metric EPNL, in units of EPNdB, as described in appendix A of this part.

316. Section B36.8(c)

Acoustic data must be adjusted to the reference conditions specified in this appendix using the methods described in appendix A of this part. Adjustments for speed and thrust must be made as described in section A36.9 of this part.

317. Section B36.8(d)

If the airplane's weight during the test is different from the weight at which noise certification is requested, the required EPNL adjustment may not exceed 2 EPNdB for each takeoff and 1 EPNdB for each approach. Data approved by the CAAC must be used to determine the variation of EPNL with weight for both takeoff and approach test conditions. The necessary EPNL adjustment for variations in approach flight path from the reference flight path must not exceed 2 EPNdB.

a. Explanation

This section specifies limits on EPNL adjustments due to differences between takeoff and approach test weight and the maximum weight at which noise certification is requested.

b. Supplemental Information

(1) Applicability of section B36.8(d): The requirements of section B36.8(d) do not apply when approved equivalent noise measurement and evaluation procedures are used to develop Noise-Power-Distance (NPD) data for airplane noise certification compliance. (See sections 2.1.2 and 3.1.2 of the appended ICAO TM).

c. Procedures

None

318. Section B36.8(e)

For approach, a steady glide path angle of 3° ± 0.5° is acceptable.

a. Explanation

This section specifies limits on airplane deviations from a 3° glide path during approach noise certification measurements.

b. Supplemental Information

(1) Applicability of section B36.8(e): The requirements of B36.8(e) regarding limits on glide path deviations do not apply when approved equivalent noise measurement and evaluation procedures are used to develop Noise-Power-Distance (NPD) data for airplane noise certification compliance (See sections 2.1.2, 2.1.1.3, 2.1.1.4, and 3.1.2(a) of the appended ICAO TM).

c. Procedures

(1) Applicant's Responsibility: The applicant is responsible either for ensuring that approach tests are conducted within specified glide path tolerances, or for obtaining approval for equivalent noise measurement and evaluation procedures if testing is not to be conducted within specified tolerances.

319. Section B36.8(f)

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 must be approved by the CAAC. The adjustments may not exceed 16 EPNdB on takeoff and 8 EPNdB on approach. If the adjustment is more than 8 EPNdB on takeoff, or more than 4 EPNdB on approach, the resulting numbers must be more than 2 EPNdB below the limit noise levels specified in section B36.5.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

(1) Integrated Method: An applicant must use the “integrated method”, specified in section A36.9.4, when approved equivalent noise measurement and evaluation procedures result in EPNdB adjustments greater than 8 EPNdB for takeoff and 4 EPNdB for approach (See requirements specified in section

A36.9.1.2).

320. Section B36.8(g)

During takeoff, lateral, and approach tests, the airplane variation in instantaneous indicated airspeed must be maintained within ±3% of the average airspeed between the 10 dB-down points. This airspeed is determined by the pilot's airspeed indicator. However, if the instantaneous indicated airspeed exceeds ±5.5 km/h (±3 knots) of the average airspeed over the 10 dB-down points, and is determined by the CAAC representative on the flight deck to be due to atmospheric turbulence, then the flight so affected must be rejected for noise certification purposes.

Note: Guidance material on the use of equivalent procedures is provided in the current advisory circular for this part.

a. Explanation

None

b. Supplemental Information

(1) Airspeed Variations: Possible causes and potential effects of airspeed variations during noise certification measurements are discussed under section A36.2.2.2(f) of this AC.

c. Procedures

None

321. - 349. [RESERVED]

XIV. APPENDIX F — FLYOVER NOISE REQUIREMENTS FOR PROPELLER – DRIVEN SMALL AIRPLANE AND PROPELLER-DRIVEN, COMMUTER CATEGORY AIRPLANE CERTIFICATION TESTS PRIOR TO NOVEMBER 17, 1988

350. PART A - GENERAL

351. Section F36.1 Scope [To be completed later.]

352. PART B - NOISE MEASUREMENT

353. Section F36.101 General Test Conditions [To be completed later.]

354. Section F36.103 Acoustical Measurement System [To be completed later.]

355. Section F36.105 Sensing, Recording, and Reproducing Equipment

356. Section F36.107 Noise Measurement Procedures [To be completed later.]

357. Section F36.109 Data Recording, Reporting, and Approval [To be completed later.

358. Section F36.111 Flight Procedures [To be completed later.]

359. PART C - DATA CORRECTION

360. Section F36.201 Correction of Data [To be completed later.]

361. Section F36.203 Validity of Results [To be completed later.]

362. PART D - NOISE LIMITS

363. Section F36.301 Aircraft Noise Limits [To be completed later.]

364. - 374. [RESERVED]

XV. Appendix G — Takeoff Noise Requirements for Propeller-Driven Small Airplane and Propeller-Driven, Commuter Category Airplane Certification Tests on or After November 17, 1988

375. PART A - GENERAL

376. Section G36.1 Scope

This appendix prescribes limiting noise levels and procedures for measuring noise and adjusting these data to standard conditions, for propeller driven small airplanes and propellerdriven, commuter category airplanes specified in §§36.1 and 36.501(c).

a. Explanation

Appendix G applies to the take-off noise requirements for propeller-driven small airplanes and commuter category airplanes that are tested on or after December 22, 1988, and that do not exceed 19,000 lbs. in maximum gross take-off weight. It is a self-contained document, that includes the procedures for testing, weather limitations, calculations of the reference performance, adjustments of measured noise level data to reference conditions, and noise level limits. It is organized in four sections:

Part A – General

Part B – Noise Measurement

Part C – Data Correction

Part D – Noise Limits

b. Procedures

Noise certification of small propeller-driven and commuter category airplanes in its most basic form requires a minimum of three actions, namely—

(1) Noise measurements conducted during a succession of take-off tests of the airplane within prescribed flight and noise measurement conditions. These

conditions are described in paragraphs 377 to 404.

(2) Corrections and adjustments of the noise level data to account for deviations in test conditions relative to a prescribed reference condition. Corrections and adjustments are described in paragraphs 405 and 415.

(3) Demonstration, reporting, and approval that the adjusted noise levels for the airplane are within the noise limit appropriate to the airplane, which is based on the maximum certificated take-off weight of the airplane. Demonstration, reporting, and noise limits are described in paragraphs 416 to 417.

377. PART B - NOISE MEASUREMENT

378. Section G36.101 General test conditions

(a) The test area must be relatively flat terrain having no excessive sound absorption characteristics such as those caused by thick, matted, or tall grass, by shrubs, or by wooded areas. No obstructions which significantly influence the sound field from the airplane may 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 degrees from the normal ground axis.

a. Explanation

It is necessary to specify test condition limits in order to avoid conditions that could affect the consistency of the sound levels at the measuring microphone. This regulation presents the requirements for the test site in order to uniformly measure noise levels. Uneven terrain having features such as mounds or furrows can result in reflections that could influence the measured sound levels. Vegetation can reduce the amount of sound that is reflected from the ground surface. In most cases this effect results in a reduced sound level, but under some circumstances the level may be higher. Similarly, testing over a smooth, hard surface, such as a paved area, will generally result in a higher sound level.

Obstructions in the vicinity of the microphone can also influence the measured levels. Objects such as buildings, walls, trees, vehicles, and, if close enough, test personnel, can constitute obstructions and/or cause reflections. The noise measure specified in Appendix G is based on the sound level at only one point in time, which for propeller-driven airplanes occurs when the airplane is

near the overhead position. Unless the microphone is under a tree or overhang, it is unlikely that an obstruction would be between the sound source and the microphone. However, nearby objects can still affect the sound because of reflections.

b. Supplemental Information

(1) Obstructions: No obstructions are permitted within a cone-shaped space centered on the microphone position, having a half-angle of 75° from the vertical (or a horizontal angle of 15° from the ground surface). At a distance of 15.2 m (50 feet) from the microphone, an object must be no taller than 4 m (13.4 feet) above the ground at the microphone location in order to meet this requirement. At a distance of 7.7 m (25 feet) from the microphone, an object on the ground must be no taller than 2.0 m (6.7 feet) above the ground at the microphone location.

c. Procedures

(1) Test Site Selection: When selecting the test site, it is necessary to consider topography, the condition of the ground surface, and nearby obstructions. Vegetation, such as shrubs and thick grass, in the vicinity of the microphone is not permitted. It is not permissible to place "soft" material around the microphone. In this context, this includes materials that do not occur naturally at the test site, such as artificial materials or soil that is prepared in such a way to make it unusually absorptive. Wet soil is not specifically addressed in the regulation, but it is likely that wet soil would result in higher measured noise levels and would therefore not be favorable to the applicant.

(2) Snow: Snow-covered surfaces are not addressed in the regulation; however, measurements under these conditions could result in lower noise levels. Conditions are considered acceptable if the snow is cleared within a radius around the microphone of approximately 15.2 m (50 feet).

379. Section G36.101(b)

(b) The tests must be carried out under the following conditions:

(1) No precipitation;

(2) Ambient air temperature between 2.2 ºC and 35 ºC (36 ºF and 95 ºF);

(3) Relative humidity between 20 percent and 95 percent, inclusively;

(4) Wind speed may not exceed 19 km/h (10 knots) and cross wind may not exceed 9 km/h (5 knots), using a 30-second average;

(5) No temperature inversion or anomalous wind condition that would significantly alter the noise level of the airplane when the nose is recorded at the required measuring point, and

(6) The meteorological measurements must be made between 1.2 m (4 ft.) and 10 m (33 ft.) above ground level. If the measurement site is within 1.85 km (1 n.m.) of an airport meteorological station, measurements from that station may be used.

a. Explanation

This section identifies the weather conditions under which noise measurements can be made. The regulatory limitations were created to provide the greatest flexibility for applicants, with minimum effect on measured or corrected noise, while providing good repeatability.

b. Supplemental Information

(1) Precipitation: Fog, rain, drizzle, and snow can have a number of adverse effects. Changes in sound generation and propagation under these conditions are not well documented. Most of the equipment used for measuring noise is not intended for use during conditions of precipitation, and the effects can range from changes in microphone and windscreen sensitivity or frequency response, to arcing of conventional condenser microphones, to possible failure of equipment because of electrical short circuits.

(2) Atmospheric Conditions: Atmospheric conditions can affect the generation and propagation of sound, for non-reference helical tip Mach numbers (see paragraph 413). Propellers generate higher noise levels at higher propeller helical tip Mach numbers. Usually the actual tip velocity is close to reference propeller tip velocity, but the speed of sound is a function of air temperature which is often different than the reference value. Off-reference tip Mach numbers can occur because of off-reference air temperature. The regulation requires correction for non-reference tip Mach numbers under most circumstances. However, limiting the permissible test temperature range reduces the potential magnitude of this correction. Corrections are also required to

account for non-reference atmospheric absorption of sound. The magnitude of this correction is also limited by restricting the range of permissible temperature and relative humidity.

(3) Nonuniform Atmosphere: The atmosphere between the source (airplane, propeller, and/or exhaust) and the microphone is not uniform. There can be strong temperature gradients (positive and negative), variations in relative humidity, and variation in wind. Turbulence is also associated with strong winds, which can cause irregular sound propagation. When there is a crosswind, it is necessary for the airplane to fly at an angle to maintain the required track over the ground. Corrections are not required to account for wind. The wind limits only provide a means of determining acceptability of the data.

(4) Weather Monitoring: Based on the above considerations, it is clearly necessary to monitor the weather conditions. Procedures used in the noise certification process for transport category airplanes and turbojet-powered airplanes call for measurement of the weather conditions between the ground and the height at which the airplane is flying (see section A36.2.2.2(b)). The absorption of sound in air can then be computed based on these measurements. This process requires an appreciable investment of time and resources. For propeller-driven airplanes, the magnitude of the adjustment for atmospheric absorption is less than that for turbojet airplanes. An adjustment procedure based on measurements of the weather near the surface is therefore considered sufficient and more appropriate for airplanes covered by this section.

c. Procedures

(1) General Weather Measurements: The applicant is required to measure weather conditions near the surface and in the vicinity of the noise measuring station. The acceptability of noise data is contingent on the conditions being within the specified limits of section G36.101(b). Under the requirements of the regulations, these measurements are to be made at a height between 1.2 meters (4 feet) and 10 meters (33 feet) above ground level. This allows the use of hand-held equipment but does not preclude the use of more complex equipment of the type identified in Appendix A of Part 36 and used during measurement of turbojet-powered airplanes if the applicant so chooses. The weather data may be recorded on a chart, or an FAA-witnessed record of the observations may be kept.

(2) Wind: Consistent with the less complex requirements for small propeller-driven airplanes, wind conditions can be measured at the time of the

airplane overflight with a relatively simple anemometer with an appropriate calibration. If the device used does not provide enough information to compute the crosswind, then the wind in any direction is limited to the crosswind limit of 5 knots. The wind limits are based on a 30-second average.

(3) Temperature and Relative Humidity Limits: Noise data are acceptable only if the air temperature is in the range from 36° to 95° Fahrenheit (F), and the relative humidity is in the range from 20 to 95 percent. Temperature and relative humidity may be measured with a psychrometer, a device that measures wet and dry bulb temperatures of the air. Relative humidity is then computed from these temperatures. Sufficient measurements should be made to determine all adjustments required by the regulations. Persons responsible for performing the test should be alert to changes in the conditions. At a minimum, measurements should be made immediately before the first run in a series and immediately after the last run. This will normally result in an interval of not more than 1 hour, because the test airplane is required to refuel after 1 hour of flight time. In marginal or changing conditions, shorter intervals would be more appropriate.

(4) Use of Airport Facility: The regulations also permit the use of airport facility weather-measuring equipment. In deciding if the equipment is suitable, it is necessary to verify: (a) that the measurements are representative of the conditions near the microphone; (b) that the equipment is providing reliable information; (c), that the equipment has recently been calibrated; and (d), and that the equipment is FAA-approved.

(5) Temperature Inversions: The effects of inversions and anomalous wind conditions are difficult to quantify. When temperature inversions are present (that is when the air temperature increases with height over any portion of the atmosphere between the ground and the aircraft), flight conditions may be unstable, which hampers the ability of the pilot to set up a consistent, stabilized climb within the permitted operational tolerances. Also, under these conditions, it is possible to have a situation in which the surface temperature and relative humidity meet the permissible test criteria but the conditions aloft are much drier, with consequent high sound absorption characteristics and the possibility of underestimating the noise level. The noise spectrum of propellerdriven airplanes contains relatively less high- frequency noise than that of jet airplanes, so the effects may not be very significant unless there is a severe inversion.

(6) Anomalous Winds: The presence of anomalous wind conditions may be assessed by noting the airspeed variation as the airplane climbs. If the wind is uniform or changes speed or direction slowly with altitude, there is no difficulty

in maintaining a constant climb speed. If there are strong variations in the wind (wind shear) or rising and descending air, there will be variations in airspeed that are not easily controllable. Variations of ±5 knots during the overflight relative to the reference velocity (Vy) are permitted by the regulation, and this criterion may be used to evaluate the presence of anomalous wind conditions.

(7) Air Temperature Measurements vs. Altitude: At the beginning of the test and, if considered necessary, at intervals during the test, an observer on the test airplane is to monitor the air temperature during a climb. This climb may be a noise data–recording climb or may be dedicated to temperature measurement. The information must be assessed if a judgment is to be made about the acceptability of the conditions for noise measurements. The presence of anomalous wind conditions can be assessed during the data acquisition.

380. Section G36.101(c)

(c) The flight test procedures, measuring equipment, and noise measurement procedures must be approved by the CAAC.

a. Explanation

All aspects of the noise certification tests that will be used to show regulatory compliance with Part 36 are to be conducted in accordance with documentation that has been reviewed and approved by the CAAC. This is best accomplished by means of a detailed test plan.

b. Supplemental Information

(1) Equivalent Procedures: Equivalent procedures for determining noise levels may be proposed by the applicant. These procedures may be developed to supplement Part 36 procedures and evaluations. Equivalent procedures are measurement or analytical methods not identical to those specified in Part 36, but which the CAAC approves as yielding equivalent results. In effect, equivalent procedures are those that are judged to provide the same certification stringency and confidence as would be obtained if the procedures were in complete compliance with Part 36. Use of equivalent procedures may be requested by applicants for many reasons, such as to:

(i) Make use of previously acquired certification test data for the airplane

type

(ii) Permit more reliable demonstration of small noise level differences among derived versions of an airplane type

(iii) Minimize the cost of demonstrating compliance with the requirements of Part 36 by keeping airplane flight time, airfield usage, and equipment and personnel costs to a minimum.

c. Procedures

(1) Test Plan: The applicant must prepare a test plan for review and approval by the FAA. The test plan is to include descriptions of the test airplane and the test site, details of all the equipment that will be used, flight limitations and procedures, and data adjustments. The approved test plan will control the performance of the tests and the analysis of the test results.

(2) Examples: An example of an equivalent procedure is the use of flight path intercepts instead of standing start take-offs (see figure in paragraph 402). Another example of an equivalent procedure is the certification of a derivative model of a parent airplane for which a complete database of noise and performance measurements was obtained during the parent model's noise certification. Under these circumstances, it may be possible to show the derivative model's noise levels by doing comparison flyover tests of the derivative prototype and the parent airplanes and documenting the changes or differences between the two.

(3) CAAC Approvals: No general rules can be stated for the acceptability of an equivalent procedure, and each such application is to be reviewed and approved by CAAC on its own merits. CAAC has the final approval authority over all equivalent procedures. Any proposed equivalent procedures are to be documented in the test plan.

381. Section G36.101(d)

(d) Sound pressure level data for noise evaluation purposes must be

obtained with acoustical equipment that complies with section G36.103 of this appendix.

382. Section G36.103 Acoustical measurement system

The acoustical measurement system must consist of approved equipment with the following characteristics:

(a) A microphone system with frequency response compatible with measurement and analysis system accuracy as prescribed in section G36.105 of this appendix.

a. Explanation

Microphones with the characteristics specified in section G36.105 are appropriate for measuring the noise of small propeller-driven airplanes.

b. Procedure

The test plan is to include a description of the proposed microphone system in a form suitable for CAAC verification of compliance with the provisions of section G36.105.

383. Section G36.103(b) & (c)

(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 section G36.105 of this appendix.

a. Explanation

The regulations call for the microphone to be mounted in an inverted position as described in section G36.107. All other support instrumentation and materials, including personnel, must be placed at sufficient distance from the microphone to avoid causing contaminating effects, such as distortion of the sound field or increased background noise. Special design for the microphone mounting system is required, to avoid interference effects from the microphone

holder legs and the edge effects of the plate. Modern digital recording equipment should not have dynamic range limitation problems in recording propeller- driven small airplane noise levels under the conditions specified.

b. Procedures

(1) Equipment Availability: The microphone support is to be designed to minimize reflections that could distort the sound field. An example of the microphone mounting is given in paragraph 391. Commercially available recording and reproducing equipment that meets the regulatory requirements of G36.105 is readily available.

384. Section G36.103(d)

(d) Acoustic calibrators using sine wave or broadband noise of known sound pressure level. If broadband noise is used, the signal must be described in terms of its average and maximum root-meansquare (rms) value for non-overload signal level.

a. Explanation

Typical acoustical calibration instruments generate either single-frequency sound or broadband sound. The noise measure and limits that are used to evaluate noise levels are defined in terms of the rootmean-square (rms) sound pressure level. With broadband noise, the level of the peaks may be many times the rms value. It is therefore necessary to verify that the peaks of a broadband signal do not exceed the dynamic range of any of the system components, which could cause erroneous results. Modern digital recording equipment should not have dynamic range limitation problems in recording propeller- driven small airplane noise levels under the conditions specified.

b. Supplemental Information

(1) Field Calibrations: It is possible to calibrate measurement and recording systems in a laboratory, and in fact this is usually done. However various circumstances, such as differing environmental conditions, may cause minor changes in equipment sensitivity. Unintentional damage may also occur during equipment setup and noise testing. Field calibrations are therefore required.

c. Procedure

(1) Acoustic Calibrations: An acoustic calibrator is to be used to calibrate

the measurement and recording system. The root-mean-square value of the calibration signal should be reported, and, if a broadband calibrator is used, the peak level should be reported. Calibration signals are to be recorded on the tape recorder (if used) at the beginning and end of each test series and at CAAC - approved intervals throughout the test when there may be any delay in the performance of the test. The system should be allowed to reach a stable operating condition in accordance with the manufacturer's recommendations prior to the initial calibration.

385. Section G36.105(a)

(a) The noise produced by the airplane must be recorded. A magnetic tape recorder, graphic level recorder, or sound level meter is acceptable when approved by the regional certificating authority.

a. Explanation

A permanent record of each noise event is required so that the results are not solely dependent on readings taken in the field as the events occur. The means of making this permanent record are subject to approval by CAAC.

b. Supplemental Information

(1) Tape Recorders: A tape recorder can be used to preserve a complete acoustical record of the events. If there are questions about the data observed during the tests, the recorded data can be replayed, multiple times if necessary, to verify the results. A more detailed analysis of the airplane noise signal may also be useful to the applicant for research and development purposes.

(2) Graphic Level Recorders: A graphic level recorder can be used to provide a permanent record of the noise levels, but no replay or reproduction of the acoustical signal is possible.

(3) Sound Level Meters: The record that results from the use of a sound level meter depends on the design features of the instrument. The least complex instrument uses an electromechanical metering mechanism, requiring the operator to observe the highest level indicated by the moving needle in the meter display during each event. Other, more complex instruments can be set to hold the maximum noise level reached during each event and show this level on a digital display. Some currently available digital units are capable of storing entire time-histories of noise levels for multiple runs. These histories can be

recalled to the instrument's display, transmitted to a printer, or downloaded to a computer.

c. Procedures

(1) Recommendation: The recommended procedure is to record each noise event on a tape recorder. This recorded data can be played back and analyzed as much as necessary to verify that consistent results have been obtained.

(2) Other Methods: Other methods are acceptable, provided that appropriate measures are taken to ensure the validity of the data, and are subject to CAAC approval. Previously-approved methods include:

(i) Obtaining a graphic level record;

(ii) Reading a sound level meter in the field as the event occurs and keeping a handwritten log;

(iii) Printing or transferring to a personal computer, the entire time - history after the test has been completed.

386. Section G36.105(b)&(c)

(b) The characteristics of the complete system must comply with the requirements in International Electrotechnical Commission (IEC) Publications No. 651, entitled "Sound Level Meters" and No. 561, entitled "Electro-acoustical Measuring Equipment for Aircraft Noise Certification" as incorporated by reference under §36.6 of this part. Sound level meters must comply with the requirements for Type 1 sound level meters as specified in IEC Publication No. 651.

(c) The response of the complete system to a sensibly plane progressive sinusoidal wave of constant amplitude must be within the tolerance limits specified in IEC Publication No. 651, over the frequency range 45 to 11,200 Hz.

a. Explanation

There are many types of microphones and recording equipment. Not all such instruments posses the performance characteristics necessary to ensure consistent and valid data measurement. Specifications in the referenced documents are applicable to equipment used for sensing and recording small-airplane noise measurements.

b. Supplemental Information

None

c. Procedure

(1) Approval of Equipment: CAAC approval of all sensing, recording, and reproducing equipment is required. The equipment to be used for the noise certification tests is to be described in the test plan in sufficient detail for the FAA to determine whether it meets the required standards.

387. Section G36.105(d)

(d) If equipment dynamic range limitations make it necessary, high frequency pre-emphasis must be added to the recording channel with the converse de-emphasis on playback. The pre-emphasis must be applied such that the instantaneous recorded sound pressure level of the noise signal between 800 and 11,200 Hz does not vary more than 20 dB between the maximum and minimum one-third octave bands.

a. Explanation

There may be circumstances in which the characteristics of the noise and the recording equipment are such that the noise signal can not be adequately recorded without additional signal conditioning. Electronic shaping of the noise signal may be used to correct this deficiency. This requirement applies only when the noise signal is recorded on a tape recorder. Modern digital recording equipment should not have dynamic range limitation problems in recording propeller- driven small-airplane noise levels under the specified conditions. Since the use of older analog equipment is permitted under Appendix G, the process of applying pre emphasis and de-emphasis to the recorded acoustical data is allowed. The process of applying pre-emphasis and de-emphasis to the recorded acoustical data is not allowed in International Civil Aviation Organization (ICAO) Annex 16 Chapter 10.

b. Supplemental Information

(1) Low-Frequency Noise: The noise spectra of propeller-driven airplanes consist primarily of lowfrequency noise generated by the propeller. Harmonics of the propeller noise are also present and contribute to the A-weighted sound level. Most of the acoustical energy is typically below 1,000 Hz, but measured noise levels can be noticeably affected by the presence of higher frequency energy due in part, to the effects of the Aweighting filter.

(2) Dynamic Range: The dynamic range available with analog recording equipmentis generally more limited than that of digital equipment., and therefore the levels of the airplane noise signal at higher frequencies may be lower than the internal noise levels of analog equipment. This effect can be overcome in some cases, by selectively increasing the levels in the higher frequencies before recording by applying preemphasis, and then applying complementary de-emphasis on playback. Typically, digital tape recorders have a dynamic range that greatly exceeds that of analog recorders, and therefore pre-emphasis is not usually required.

(3) PreEmphasis Systems: Use of preemphasis will only be allowed if the system also employs complementary de-emphasis. Attempts to compensate for the effects of a pre-emphasis filter by applying onethird octave de-emphasis corrections (either numerically to analyzed data or on a band-by-band basis using separate gain stages for each one-third-octave filter) will not be accepted by CAAC. In addition, use of a preemphasis/de-emphasis system will require testing and documentation of the filters and gain stages involved to ensure that any errors are quantified and minimized and that the system performs predictably and reliably.

c. Procedure

(1) The need for preemphasis of the noise signal should be assessed, and the appropriate equipment should be included in the recording/playback system if necessary.

388. Section G36.105(e)

(e) The output noise signal must be read through an "A" filter with dynamic characteristics designated "slow" as defined in IEC Publication No. 651. A graphic level recorder, sound level meter, or digital equivalent may be used.

a. Explanation

This section is limited to providing basic guidance on the requirements of Part 36 Appendix G.

b. Supplemental Information

(1) Filtered Noise Level: The noise level from each flyover test is to be measured in terms of the maximum A-weighted sound level, in decibel (dB (A)) units, using an A-weighting filter with dynamic characteristics (or meter

response characteristics) designated as "slow," as defined in IEC 61672-1, "Sound Level Meters." The A-weighting curve is used to account for the combined effects of hearing acuity and human perception of loudness. In effect, human perception of sound is generally less sensitive at lower frequencies, increases with frequency, up to about 4,000 Hz, and decreases for frequencies greater than 4,000 Hz.

(2) Basis of Measurement: The A-weighting correction curve has been precisely defined by national and international standards (e.g., IEC 81872-1) for the measurement of sound (such as environmental noise) and is a standard feature in sound level meters and other sound analysis equipment used for noise assessments. When used for this purpose, a sound level meter will provide a "thermometer-type" rating of the audible sound. This rating (or scale) is known as the A-weighted sound level and has been scientifically proven to be a good indicator of the perceived loudness of sounds. The measurement of an A-weighted sound level requires at least three separate and precise calculations, each of which must be built into sound level meters complying with national and international standards. The sound field measured by the microphone is comprised of fluctuations in sound pressure, which are first converted to an equivalently fluctuating electrical signal by the microphone. This signal passes through the A-weighting (frequency) filter and is subsequently time-averaged to provide a more stable electrical signal that fluctuates much more slowly. The level of this time-averaged signal is converted to a logarithmic scale, using units known as decibels (abbreviated as “dB”). The A-weighted sound level is displayed in units of dB (A), denoting A-weighted sound pressure level, referenced to a sound pressure of 20 micropascals. This sound pressure, equal to a level of zero dB, represents the standardized threshold of human audibility for a tonal sound at a frequency of 1,000 Hz.

(3) Meter Response Speed: A sound level meter will (typically) have two options for time averaging - namely, "fast" and "slow" meter responses. These options govern the rate of fluctuation of the meter's needle or indicator when the sound is rapidly varying. In effect, the fast response is extremely difficult to read on a meter when a noise level is varying. The slow response is easier to read. An effective 2-second averaging period (1-second time constant) results in the slow response, which should be used in the Part 36 Appendix G noise tests.

(4) Maximum Sound Level: As would be expected, the measured or indicated A-weighted sound level will increase as the airplane approaches the measurement site and will decrease after the airplane passes over the site. The

highest value of the A-weighted sound level that occurs during the overflight is called the maximum A-weighted sound level. This is the value that must be measured during each test. Note carefully that this maximum value may not occur at the exact moment when the airplane is directly over the microphone. It usually occurs slightly before or after the airplane reaches the overhead position due to the directivity characteristics of propeller, engine, and exhaust noise emissions.

c. Procedure

(1) Equipment Requirements: The sound level recording equipment to be used for the tests must be described in the test plan in sufficient detail for the CAAC to determine whether it meets the required standards. In using a graphic level recorder, it is important to set the writing characteristics to correspond to the slow sound level meter response, as required by the regulation.

389. Section G36.105(f)

(f) The equipment must be acoustically calibrated using facilities for acoustic free-field calibration and if analysis of the tape recording is requested by the Administrator, the analysis equipment shall be electronically calibrated by a method approved by the CAAC. Calibrations shall be performed, as appropriate, in accordance with paragraphs A36.3.8 and A36.3.9 of appendix A of this part.

a. Explanation

All noise levels measured in the field or from tape-recorded data are to be determined with reference to a known sound pressure level. The most reliable way to accomplish this is to calibrate equipment with a noise source of known magnitude (i.e., a calibrator) and to compare the levels of airplane noise signals with this known source.

b. Supplemental Information

(1) Noise Level Variability: There can be variability in the noise levels indicated by the test equipment, primarily due to environmental factors and the internal warm-up that is required by most types of equipment. Occasionally, there may be other changes due to cable problems or even equipment damage. Proper use of acoustic calibration devices can help identify such occurrences.

c. Procedure

(1) Equipment Calibration: A suitable acoustic calibrator is to be used to provide a reference sound level. This is usually accomplished by placing the calibrator on the microphone and adjusting the gain of the measuring system so that the reading corresponds to the known sound level of the calibrator. Initial, final, and periodic calibrations should be used to verify that any changes in sensitivity are within the limit specified in section A36.3.8. It is important that the manufacturer's recommended system warm-up time be observed in the field prior to equipment calibration. Calibration equipment should be identified in the test plan and is to be CAAC approved.

390. Section G36.105(g)

(g) A windscreen must be employed with the microphone during all measurements of aircraft noise when the wind speed is in excess of 9 km/h (5 knots).

a. Explanation

Under windy conditions, turbulence can cause the microphone to respond in a way that is indistinguishable from its response to airplane noise. Use of a suitable windscreen over the microphone can reduce the effects of turbulence.

Windscreen corrections must be applied to the measured sound pressure levels if a windscreen is used during the measurements. The applicant must furnish data substantiating the correction.

ICAO Annex 16 Chapter 10 does not require the use of windscreens for inverted microphones.

b. Supplemental Information

(1) Turbulence: Microphones are designed to respond to pressures, primarily the fluctuating pressures of acoustic signals. A fluctuating pressure can also occur as a result of turbulence from air flowing over the sensing surface of the microphone, or from the physical presence of the microphone body in the air flow. These effects can significantly influence the measured noise level. The windscreen is to be of a designthat minimizes interference with the acoustic signal.

c. Procedure

(1) Use of Windscreens: The use of a windscreen is mandated when the wind speed exceeds 5 knots. It is recommended that a windscreen be used at all

times, not only because of the added protection it provides for the microphone, but also to enable uninterrupted measurements when the wind speed is fluctuating above and below 5 knots.

391. Section G36.107 Noise measurement

(a) The microphone must be a pressure type, 12.7 mm in diameter, with a protective grid, mounted in an inverted position such that the microphone diaphragm is 7 mm above and parallel to a white-painted metal circular plate. This white-painted metal plate shall be 40 cm in diameter and at least 2.5 mm thick. The plate shall be placed horizontally and flush with the surrounding ground surface with no cavities below the plate. The microphone must be located three-quarters of the distance from the center to the back edge of the plate along a radius normal to the line of flight of the test airplane.

a. Explanation

The Part 36 sections for large transports (Appendix C) and helicopters (Appendices H and J) require a microphone setup with the sensing element mounted 4 feet. (1.2m) above ground level. Appendix G is the only section of Part 36 that requires a microphone-mounting arrangement other than a 4 foot pole microphone. For Appendix G tests, the microphone is mounted in an inverted position so that the diaphragm is 7 millimeters (mm) above and parallel to a white-painted metal circular plate. The plate must be 40 centimeter (cm) in diameter and at least 2.5 mm thick. The plate is placed horizontally and flush with the surrounding ground surface with no cavities below the plate. The microphone is located three-quarters of the distance from the center to the edge of the plate along a radius normal to the line of flight of the test airplane. Figure 13 shows a typical inverted microphone installation.

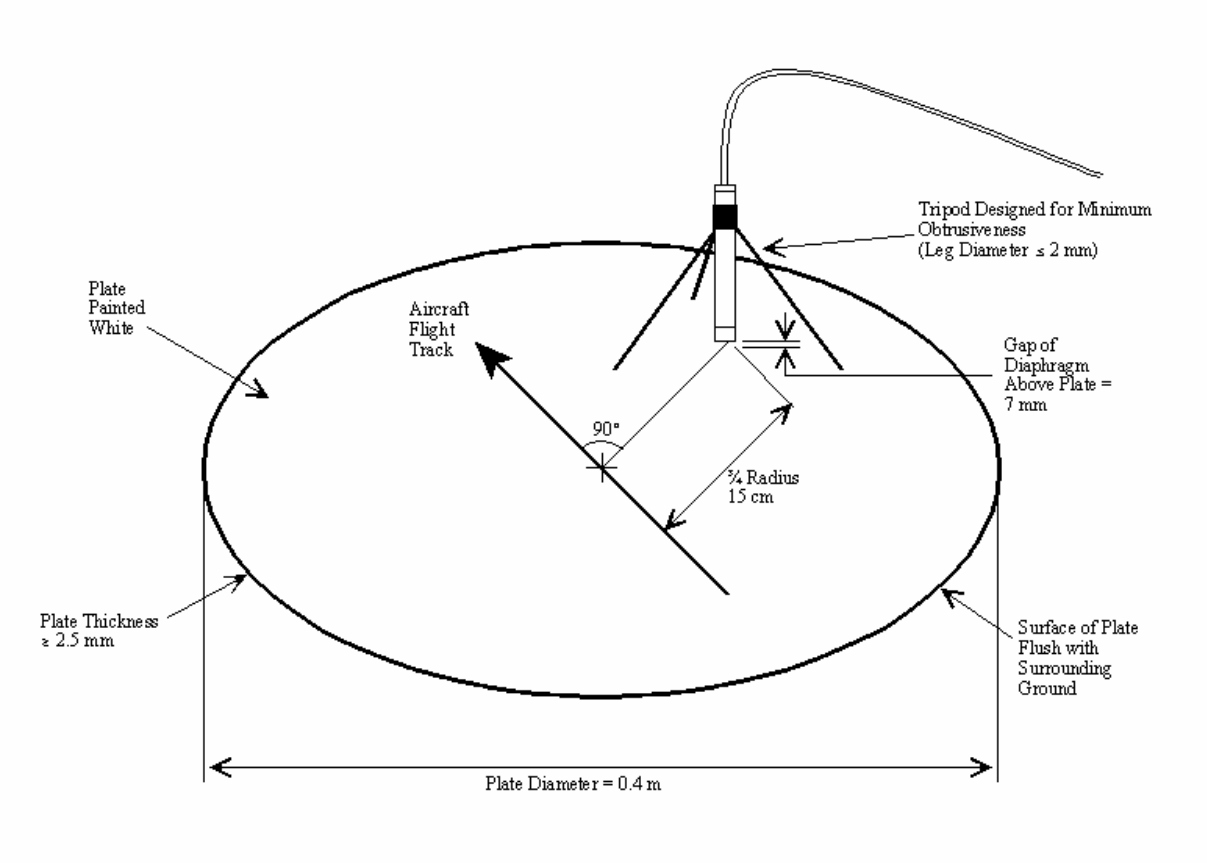


Figure 13: Configuration for ½ in. Inverted Microphone Over Plate

The inverted microphone setup in the above figure should be taken as an example of the design and construction of the microphone holder and the ground plate. The legs of the microphone holder must be firmly attached to the plate so that the microphone holder does not vibrate during the test. The plate must be painted white to reflect the sun's rays; such reflection will reduce the thermal effects on the microphone -sensing element. A metal spacer in the shape of a coin is a practical tool to use in setting the space between the microphone diaphragm and the ground plate. The spacer thickness should be 7 mm minus the space between the microphone protective grid and the microphone diaphragm.

Microphone sensitivity changes with frequency and the angle at which the sound reaches the microphone. To obtain consistent results, it is necessary to set up the microphone so that these changes do not influence the measured noise level.

The specified ground plane microphone configuration greatly minimizes the interference effects of reflected sound waves inherent in pole-mounted microphone installations. For a 4 foot microphone, such effects typically occur in the frequency region that is most significant for propeller-driven aircraft noise.

b. Supplemental Information

(1) Microphone Sensitivity: The specified ground plane configuration places the microphone diaphragm into an effective sound pressure field for the frequency range of interest. Microphones designed for uniform pressure response are appropriate for use in such installations.

(2) Microphone Placement: The spacing of the microphone diaphragm relative to the plate is critical, since it must be inserted completely within the effective sound pressure field, and the depth of this field varies with frequency and sensor size. For frequencies of interest, the 7 mm spacing has been determined to provide the best compromise of associated technical considerations.

(3) Alternate Configurations: The specifications for plate material, dimensions, and installation in the local ground surface represent the best practical method for obtaining an effective sound pressure field for the frequencies of interest. Experiments have been performed with many alternative configurations; however, only the configuration specified in the regulation will be accepted for Appendix G noise certification purposes.

c. Procedures

(1) Plate Installation in Local Ground Surface: Care must be taken during installation to ensure that the ground surface beneath the plate is level and contains no voids or gaps. One way to achieve this is by pressing the plate into the ground surface at the desired location, applying slight pressure, then removing the plate to determine if any areas under the plate are recessed. These recesses can then be filled - in with loose material, such as sand or soil, to obtain a level, uniform underlying surface. Care must also be taken to ensure that the edges of the plate are flush with the surrounding ground surface. This is especially important for plates that are thicker than the specified minimum of 2.5 mm. In some cases it may be appropriate to moisten the soil with water immediately before installation, to allow the surface to mold itself around the plate. In such cases, acoustical measurements should not be performed until the ground has dried.

(2) Design and Construction of Microphone Support: The support should be designed so that it minimizes any potential interference with sound waves from the aircraft arriving in the vicinity of the microphone. If a spider-like structure such as that in the illustration of Figure 13 is used, the number of legs should be limited to three or four. As specified, the legs must be no larger than 2

mm in diameter. Ideally the support collar should be as small as possible, and it should also implement some sort of tightening device, such as a set screw, to facilitate adjustment of the microphone diaphragm height above the plate. The support must be stable and must orient the microphone in such a way that the diaphragm is parallel to the plate.

(3) Cable Support: In some cases, it may be desirable to provide additional support to the microphone cable as it leads away from the plate. A metal rod or similar sort of support may be used for this purpose. Any such support should be as small as possible and located as far away from the plate as is practical. The microphone cable should lead directly away from the plate without crossing above any more of the plate's surface than is necessary.

(4) Microphone Height Determination: A practical method for ensuring that the microphone diaphragm is located at the specified height above the plate is to use a temporary metal spacer. This temporary metal spacer should be constructed so that when inserted between the microphone's protective grid and the plate's surface, the diaphragm is located at the 7 mm height. For most microphones of the specified type, the spacing between the protective grid and the diaphragm is about 1 to 1.5 mm. Once the microphone support mechanism has been secured, the spacer is removed. The height of the spacer must account for the distance between the protective grid and the diaphragm.

(5) Windscreens: The use of windscreens is required when wind speed exceeds 5 knots. The applicant must provide data to substantiate data adjustments for windscreen insertion-loss.

392. Section G36.107(b)

Immediately prior to and after each test, a recorded acoustic calibration of the system must be made in the field with an acoustic calibrator for the purposes of checking system sensitivity and providing an acoustic reference level for the analysis of the sound level data. If a tape recorder or graphic level recorder is used, the frequency response of the electrical system must be determined at a level within 10 dB of the full-scale reading used during the test, utilizing pink or pseudorandom noise.

a. Explanation

Acoustic calibration is required at the beginning and end of each day of testing to verify that the noise sensing, measurement, and recording equipment

has maintained its quality and sensitivity.

b. Supplemental Information

(1) Component Check: The sensitivity of various components of the recording system can change during a test. These changes may result from changes in the environment (primarily temperature) or for other causes. Usually, if the equipment is turned on and allowed to stabilize before the first calibration, any changes during the test period will be small. Any remaining substantial changes in sensitivity may be symptoms of equipment problems.

c. Procedures

(1) Calibrations: An acoustic calibrator is to be used at the start of the tests, and the system's sound level indication should be adjusted to the known sound output level of the calibrator. The readout, indicator, or display of the system, with calibrator applied, should then be read at various intervals and at the end of the tests. Any change in sensitivity should be within manufacturer's tolerances. If a tape recorder or graphic level recorder is used, the frequency response can be evaluated by the application of an appropriate input signal (such as pink noise, or swept-sine) and subsequent analysis of the recorded signal. The output level should be uniform as a function of frequency, within the specifications provided by the manufacturer. This procedure can be carried out in the laboratory before the start of the tests.

(2) Excessive Drift: When the measured level of the calibration at the end of the day's testing is within ±0.1 dB of the calibration value at the start of the day's testing, it can be judged that the system sensitivity did not excessively drift and that the test results are acceptable as-is. When a comparison between calibration levels measured at the start and the end of the day's testing indicates a drift in excess of ±0.1 dB, but within ±1.0 dB, a calibration drift adjustment is to be applied to all measured data as follows: Subtract the calibration signal level measured at the end of the test from the calibration signal level measured at the start of the test. Divide this difference by 2, then add the resulting calibration drift adjustment to all measured levels. If the difference in calibration levels measured at the start and the end of the day's testing exceeds ±1.0 dB, the measured data are not valid for certification use.

393. Section G36.107(c)

The ambient noise, including both acoustic background and electrical

systems noise, must be recorded and determined in the test area with the system gain set at levels which will be used for aircraft noise measurements. If aircraft sound pressure levels do not exceed the background sound pressure levels by at least 10 dB(A), a takeoff measurement point nearer to the start of the takeoff roll must be used and the results must be adjusted to the reference measurement point by an approved method.

a. Explanation

Under some circumstances, the ambient noise from other sound sources in the vicinity of the test site can have an effect on the measured airplane noise levels. Measurement options (such as site selection, instrumentation configuration, etc.) should be explored in order o ensure that the measured airplane noise level is at least 10 dB (A) greater than the combined background noise.

One of the reasons that this provision is included in the regulations is to address the specifics of measuring the noise levels of aerobatic airplanes. Such airplanes, with their high climb rates, may fly high enough over the measuring location that the measured airplane noise levels do not exceed the ambient noise levels by 10 dB (A). In these circumstances, the method described in this section and shown in Figure 14 may be used. For airplanes other than aerobatic airplanes, the method described in this section can only be used after authority approval has been obtained.

Annex 16 does not have a corresponding provision, since the ICAO Annex 16 standard exempts aerobatic airplanes from noise certification.

b. Supplemental Information

(1) Background Noise: Typically, with instrumentation properly configured, the electrical background noise will be substantially lower than the level of the airplane noise signal, and achieving a 10 dB (A) difference will not be difficult. If the ambient noise from other sources (e.g., highway, fixed power equipment) is within 10 dB (A) of the airplane noise, the applicant has two options. A quieter site can be selected (this is the best option) or the flight procedure can be changed so that the noise level of the airplane is higher. The latter case is equivalent to measuring the noise at a point closer to the start of take-off roll.

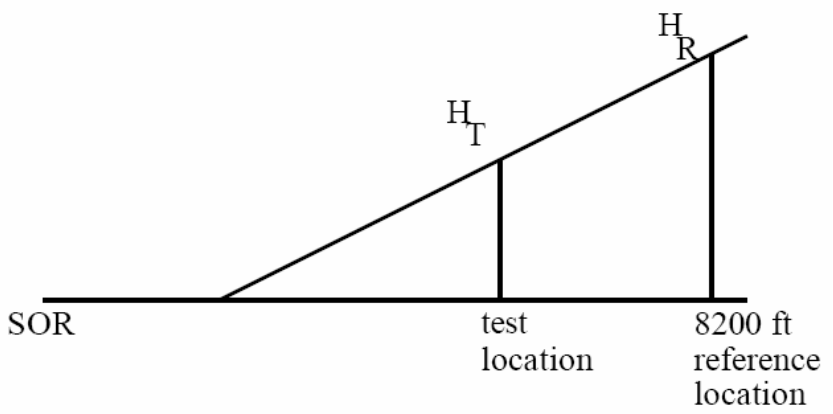


Figure 14: Adjusted Measurement Location (method is intended for highperformance airplanes)

c. Procedures

(1) Increased Airplane Noise: If a site with lower noise levels cannot be used, it will be necessary to fly the airplane so that the target height over the microphone is less than it would be at the reference microphone station (8,200 feet from the start of the take-off roll) as shown in Figure 14. In this case, the airplane height at the microphone location is likely to be outside the ±20 percent tolerance specified in the regulation. Adjustment of data to reference conditions should be performed in an approved manner.

(2) Reporting Requirements: Background noise levels are to be reported to the CAAC in the compliance documentation.

394. Section G36.109 Data Recording, Reporting and Approval

(a) Data representing physical measurements and adjustments to measured data must 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 adjustments must be approved. Estimates must be made of the individual errors inherent in each of the operations employed in obtaining the final data.

a. Explanation

Complete documentation of the measurement program should be provided as part of the permanent record of the noise tests. The regulation provides procedures for adjusting the measured data to reference conditions. The operational and weather data and the associated adjustments are to be included in the report.

b. Supplemental Information

(1) Non-reported corrections: Some corrections, such as those for frequency response of various system components, do not have to be reported if they are normal characteristics of the equipment. These corrections should be minor if the equipment meets the requirements of the regulation. Possible errors due to equipment characteristics will usually be small.

c. Procedure

(1) Data Reporting: All of the data recorded during the test program are to be reported. Any problems with the measurement system and any adjustments that were required in addition to those specified in the regulations are to be reported.

(2) Reporting Potential Errors: In most cases, potential errors due to characteristics of the measurement system should not be significant, but an assessment of these possible errors is required.

395. Section G36.109(b)

Measured and corrected sound pressure levels obtained with equipment conforming to the specifications in section G36.105 of this appendix must be reported.

a. Explanation

This section identifies the noise level reporting requirements for Appendix G noise certification testing.

b. Supplemental Information

None.

c. Procedure

None.

396. Section G36.109(c) & (d)

(c) The type of equipment used for measurement and analysis of all acoustical, airplane performance, and meteorological data must be reported.

(d) The following atmospheric data, measured immediately before, after, or during each test at the observation points prescribed in section G36.101 of

this appendix must be reported:

(1) Ambient temperature and relative humidity.

(2) Maximum and average wind speeds and directions for each run.

a. Explanation

This section presents the Appendix G atmospheric reporting requirements.

b. Supplemental Information

(1) Regulatory Interpretation: The regulation identifies "each test" and "each run." For clarification, this regulation refers to each test series (test) and each test overflight (run). The (meteorological) measurements should be made at the time of each test run, since each noise measurement will be corrected by use of the meteorological data.

(2) Wind Measurement: The requirements of section G36.101(b)(4) (paragraph 378, above) set the limits on testing, based on a 30-second average wind not to exceed 10 knots, with a 5-knot crosswind limitation. There are no additional limitations based on the surface wind. It is sufficient to report the 30-second average wind and crosswind that are within the regulatory limitations for each test overflight measurement.

c. Procedure

None.

397. Section G36.109(e)

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

a. Explanation

Sufficient information regarding the local topography and test site characteristics should be recorded and reported to show that the requirements of section G36.101(a) have been satisfied.

b. Procedure

None.

c. Procedures

(1) Sufficient information should be provided to show that the requirements

of section G36.101(a) have been met.

398. Section G36.109(f)

The aircraft position relative to the takeoff reference flight path must be determined by an approved method independent of normal flight instrumentation, such as radar tracking, theodolite triangulation, or photographic scaling techniques.

a. Explanation

Recorded noise level data adjustments include those based on the height of the airplane above the microphone station. The acceptability of each data run is also based on the lateral angular offset at the microphone station. An independent approved method is to be utilized to determine the airplane position relative to the approved flight track and height over the microphone.

b. Procedure

None.

c. Procedures

Airplane Position: The height and the angular offset from the vertical at the microphone position are to be determined by an approved method, evaluated to be within the test limitations, and reported.

399. Section G36.109(g)

The following airplane information must be reported:

(1) Type, model, and serial numbers (if any) of airplanes, engines, and propellers;

(2) Any modifications or nonstandard equipment likely to affect the noise characteristics of the airplane;

(3) Maximum certificated takeoff weight;

(4) For each test flight, airspeed and ambient temperature at the flyover altitude over the measuring site determined by properly calibrated instruments;

(5) For each test flight, engine performance parameters, such as manifold pressure or power, propeller speed (RPM) and other relevant

parameters. Each parameter must be determined by properly calibrated instruments. For instance, propeller RPM must be validated by an independent device accurate to within ±1 percent, when the airplane is equipped with a mechanical tachometer.

(6) Airspeed, position, and performance data necessary to make the corrections required in section G36.201 of this appendix must be recorded by an approved method when the airplane is directly over the measuring site.

a. Explanation

These airplane parameters must be determined and reported to determine the engine and propeller test conditions that are used for adjusting the noise level data to reference conditions.

b. Supplemental Information

Required Measurements: These parameters are required in order to provide the information used in the adjustment process. Mechanical tachometers are subject to potential indicating errors as a result of the cable drive system. Separate validation of the in-flight reading is therefore required if a mechanical tachometer is used. All equipment utilized to determine the required parameters is to be calibrated, and the calibrations are to be applied before being reported to the CAAC in the test report and before being used to make reference airplane corrections. The temperature at the airplane height is required for tip Mach number correction.

c. Procedures

None.

400. Section G36.111 Flight procedures

(a) The noise measurement point is on the extended centerline of the runway at a distance of 2500 m (8200 ft) from the start of takeoff roll. The aircraft must pass over the measurement point within ±10 degrees from the vertical and within 20% of the reference altitude. The flight test program shall be initiated at the maximum approved takeoff weight and the weight shall be adjusted back to this maximum weight after each hour of flight time. Each flight test must be conducted at the speed for the best rate of climb (V_y) ±9 km/h (±5 knots) indicated airspeed. All test, measurement, and data correction procedures must be approved by the CAAC.

a. Explanation

This regulation identifies the overhead flight position (height and lateral position) of the airplane during noise certification testing. The CAAC-approved airplane weight and airspeed are controlled by this regulation.

b. Supplemental Information

(1) Airplane Position: The regulation requires determination of the noise level at a single location, specified relative to the start of take-off roll. Limits on the permissible deviation from the reference flight path are specified for the flight tests. These limits are based on the ability to obtain consistent, representative results, without placing excessive restrictions on the flight test. The initial take-off weight is required to be equal to the maximum approved take-off weight, and after an hour of flight time, the weight is to be increased back to this weight to account for fuel burn. This procedure ensures that the flight parameters, primarily angle of attack, do not vary significantly from the reference. The airplane position is to be FAA approved for each test overflight.

(2) Best Climb Speed: The choice of V_y for the climb speed is representative of actual airport operations. These speeds, and the resulting rate of climb, are usually available in the documentation (Pilot's Operating Handbook and/or Approved Flight Manual). The tolerance of ±5 knots from this speed allows for normal variations due to pilot technique. Variations in excess of this would be an indication of turbulence and/or anomalous winds, conditions that are unsuitable for testing.

(3) Lateral Deviation: The approved deviation tolerance of 10° from the vertical can result in a reduction in measured noise level of approximately 0.1 dB, relative to the noise level for flight directly over the microphone. There are no specified corrections for this. Deviations from the reference height can occur for many reasons, including wind, airplane weight, test site elevation, and temperatures, as well as the procedure used to calculate the reference height (in section G36.111(b)). The regulation permits test heights to be within ±20 percent of the reference and requires an adjustment to account for the difference.

c. Procedures

(1) Normal Take-off: Unless an equivalent procedure is used, the airplane takes off in a normal manner and is then set up in a climb. The noise level is measured at a point 2,500 m (8,200 feet) from the start of take-off roll.

(2) Equivalent Procedure: In practice, most applicants elect to use an

equivalent procedure referred to as an intercept technique. In this technique, the airplane remains in flight and intercepts as closely as possible the reference climb path. The intercept height and location may be varied so that the correct height ±20 percent is achieved at the microphone. This procedure is acceptable because the noise level is measured only when it is at a maximum, and any maneuvering before and after that time does not affect the result, as long as the operational parameters are stabilized.

401. Section G36.111(b)

The takeoff reference flight path must be calculated for the following atmospheric conditions:

(1) Sea level atmospheric pressure of 1013.25 hPa;

(2) Ambient air temperature of 15 °C (59 °F);

(3) Relative humidity of 70 percent; and

(4) Zero wind.

a. Explanation

This regulatory section identifies the reference atmospheric conditions for noise certification testing.

b. Procedures

(1) Calculation of the take-off reference flight path is a simplified representation of actual take-off and climb procedures. For the purpose of this part of the regulation, it is assumed that the atmosphere is homogeneous throughout the take-off and climb, with no change of air pressure, temperature, or relative humidity, and no wind. The selected conditions correspond to sea level and standard atmosphere, with the exception of the relative humidity. The combination of 59°F and a relative humidity of 70 percent results in low absorption of sound as it propagates from the airplane to the ground, representing a worst-case scenario for the noise certification evaluation.

(2) A worked example of reference flyover height and reference conditions for source noise adjustments is provided in Appendix 5 of the Technical Manual (TM).

402. Section G36.111(c)

The takeoff reference flight path must be calculated assuming the following two segments:

a. Explanation

For analysis purposes, the flight path is separated into two segments, namely take-off roll and climb segments, as discussed in paragraphs 403 and 404, below.

The term “segment” is typically used in performance testing of airplanes and should not be confused with noise certification flight path segments. ICAO Annex 16 Chapter 10 uses the term “phases” to avoid confusion.

b. Supplemental Information

(1) Available Information: For the purpose of noise certification, the assumed take-off flight path is considerably less complex than an actual take-off, which consists of more than two segments. The assumed take-off flight paths are an artificial situation used only for noise certification purposes. Calculation of the reference flight path requires only information that is readily available to the applicant and published in the Pilot's Operating Handbook and/or Approved Flight Manual.

(2) Approval Requirements: Any information used in these data corrections or analysis calculations are to be CAAC approved.

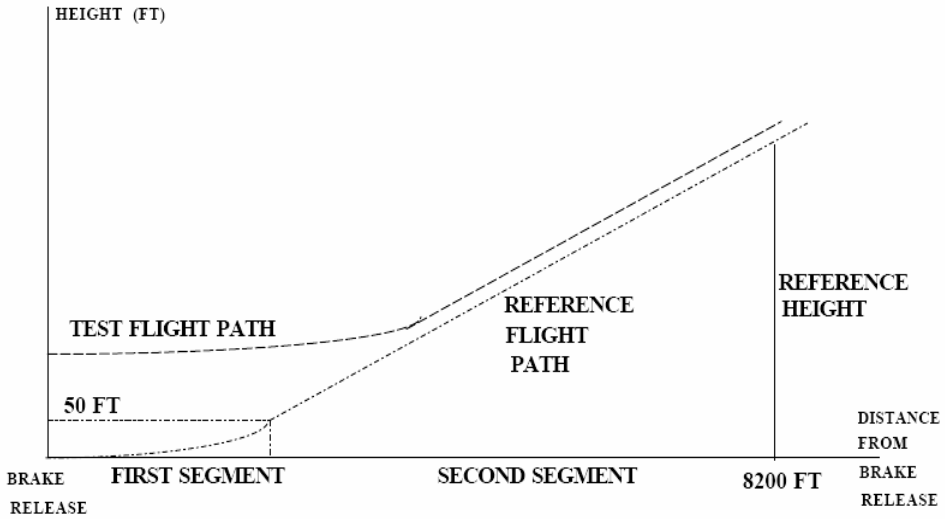


Figure 15: Typical Test and Reference Flight Paths

Figure 15, shown above, illustrates the difference between the test and the reference flight paths. Calculations may be used to determine corrections to the measured noise levels to account for the difference between the flight paths. For

a sample calculation of reference and test conditions, see Appendix 5 of the Technical Manual (TM).

c. Procedure

Any information used in these calculations is to be CAAC approved.

403. Section G36.111(c)(1)

First segment.

(i) Takeoff power must be used from the brake release point to the point at which the height of 15 m (50 ft) above the runway is reached.

(ii) A constant takeoff configuration selected by the applicant must be maintained through this segment.

(iii) The maximum weight of the airplane at brake-release must be the maximum for which noise certification is requested.

(iv) The length of this first segment must correspond to the airworthiness approved value for a takeoff on a level paved runway (or the corresponding value for seaplanes).

a. Explanation

The airplane weight used in the calculation is the maximum take-off weight. The first segment starts at the point of brake release and ends at the point where the airplane reaches a height of 50 feet above the runway.

b. Supplemental Information

(1) Airplane Configuration: Usually, the applicant will select a flap setting that minimizes the takeoff distance to 50 feet. In some cases, there may be an advantage in selecting the position of the center of gravity to further reduce the take-off roll. There is no requirement to use the selected center of gravity position during the actual testing, nor does it become an operating limitation. The take-off configuration may be any configuration that is approved from an airworthiness point of view, and the distance required to reach a height of 50 feet is to be that listed in approved documentation.

c. Procedure

(1) Airplane Performance: The required reference airplane performance data are to be determined from approved available information (e.g., the Airplane Flight Manual).

404. Section G36.111(c)(2)

Second segment.

(i) The beginning of the second segment corresponds to the end of the first segment.

(ii) The airplane must be in the climb configuration with landing gear up, if retractable, and flap setting corresponding to normal climb position throughout this second segment.

(iii) The airplane speed must be the speed for the best rate of climb (V_y).

(iv) For airplanes equipped with fixed pitch propellers, takeoff power must be maintained throughout the second segment. For airplanes equipped with variable pitch or constant speed propellers, takeoff power and RPM must be maintained throughout the second segment. If airworthiness limitations do not allow the application of takeoff power and RPM up to the reference point, then takeoff power and RPM must be maintained for as long as is permitted by such limitations; thereafter, maximum continuous power and RPM must be maintained. Maximum time allowed at takeoff power under the airworthiness standards must be used in the second segment. The reference height must be calculated assuming climb gradients appropriate to each power setting used.

a. Explanation

This section presents the regulatory requirements for the climb segment, which extends from the point where the airplane reaches a height of 50 feet (end of the take-off segment) to a point over the microphone at a distance of 8,200 feet from brake release. It is assumed that this segment is at a constant climb gradient, constant configuration, and constant airspeed.

The engine power requirement for the second segment is an unharmonized item between Part 36 and Annex 16. Part 36 Appendix G allows the use of maximum continuous installed power for variable-pitch propellers during the second segment of the flight path, where as Annex 16 Chapter 10 requires maximum power if the engine is not time limited.

b. Supplemental Information

(1) Normal Take-off and Climb: In an actual take-off and climb situation, as the airplane climbs, the climb gradient, configuration, and airspeed may continuously change. In practice, the airspeed, engine power, landing gear position, and aerodynamic configuration (flap setting) at the end of the first segment cannot instantaneously change to those used in the reference calculation

of the second segment.

(2) Reference Performance: For regulatory purposes, it is assumed that the airplane configuration, airspeed, and climb gradient instantaneously change following the first segment and remain constant throughout the second segment.

(3) Airspeed: The airspeed for the best rate of climb (V_y) is typical of that used in actual airport operations and that which is determined during the airworthiness certification for the airplane.

(4) Flap Settings: The airplane must be flown in constant configuration during the second segment.

(5) Configuration: There are different requirements for fixed, and variable-pitch propellers because of the different operational characteristics. A discussion of the issues that are relevant to noise certification is provided in paragraph 339, below. In an actual take-off situation, as the airplane climbs, the climb gradient changes.

c. Procedure

(1) Applicant's Responsibility: The applicant is to determine the appropriate climb flap setting and airspeed from the airplane certification documentation (e.g., Airplane Flight Manual).

405. PART C - DATA CORRECTION

406. [RESERVED]

407. Section G36.201 Correction of Data

(a) These corrections account for the effects of:

(1) Differences in atmospheric absorption of sound between meteorological test conditions and reference conditions.

(2) Differences in the noise path length between the actual airplane flight path and the reference flight path.

(3) The change in the helical tip Mach number between test and reference conditions.

(4) The change in the engine power between test and reference conditions.

a. Explanation

Corrections are required to account for differences between the noise certification test conditions and the reference conditions.

The required corrections falls into two groups present below:

Corrections to the noise levels for atmospheric absorption of sound to adjust them to acoustical reference temperature (59°F) and relative humidity (70 percent).

Corrections to the noise levels to account for differences in propeller tip helical Mach number and engine power (of the actual flights) relative to those intended under reference conditions. The term "reference conditions" is used repeatedly in 14 CFR Part 36 Appendix G and means conditions that would occur if the airplane were flown "textbook fashion" for a Vy take-off under standard atmospheric conditions (i.e., sea level, 59°F).

Most of these corrections require some calculations before the test program starts (i.e., to determine the reference conditions) and immediately after each test flight or series of test flights.

b. Supplemental Information

(1) Atmospheric Absorption: The temperature and relative humidity of the air affect the sound propagation. This correction accounts for the difference in atmospheric absorption along the sound propagation path that occurs between temperature and relative humidity under noise certification test conditions and temperature and relative humidity under reference conditions (59°F and 70 percent Relative Humidity). Refer to paragraphs 408 and 411, below, for additional atmospheric absorption correction information.

(2) Noise Path Length: As stated in paragraph 400, above, the airplane test limitations are as follows: (a) height over the microphone within ± 20 percent of the reference height; and (b) lateral position within ±10° of the vertical. The noise path length correction adjusts the measured noise levels for the difference in noise path length between actual noise test conditions and reference conditions. Refer to paragraph 411, below, for additional path length correction information.

(3) Helical Tip Mach Number: The noise generated by a propeller-driven airplane depends on the rotational speed of the tip of the propeller, more specifically the helical tip Mach number. Data corrections are based on the relationship between the helical tip Mach numbers determined for test and reference conditions. Refer to paragraphs 409 and 413, below, for additional

helical tip Mach number correction information.

(4) Engine Power: Corrections are required to account for non-reference engine power settings that are used during noise certification tests. The procedures for determining of the engine power to be used in the calculations depend on the design characteristics of the engine-propeller combination. In most cases, this power is not published, and does not have to be determined for airworthiness purposes. It is therefore necessary to determine the power for noise certification purposes. Refer to paragraph 414, below, for further engine power adjustment discussion.

c. Procedures

(1) Test Conditions: The noise certification test conditions of ambient temperature, relative humidity, propeller rotational speed, airplane height and engine power are to be measured or determined by an approved method during each test overflight.

(2) Reference Conditions: The certification reference conditions of propeller rotational speed, airplane height, and engine power are to be determined at reference conditions corresponding to sea level, 59°F and 70 percent relative humidity by an approved method.

408. Section G36.201(b)

Atmospheric absorption correction is required for noise data obtained when the test conditions are outside those specified in Figure G1. Noise data outside the applicable range must be corrected to 15ºC (59ºF) and 70 percent relative humidity by an CAAC approved method.

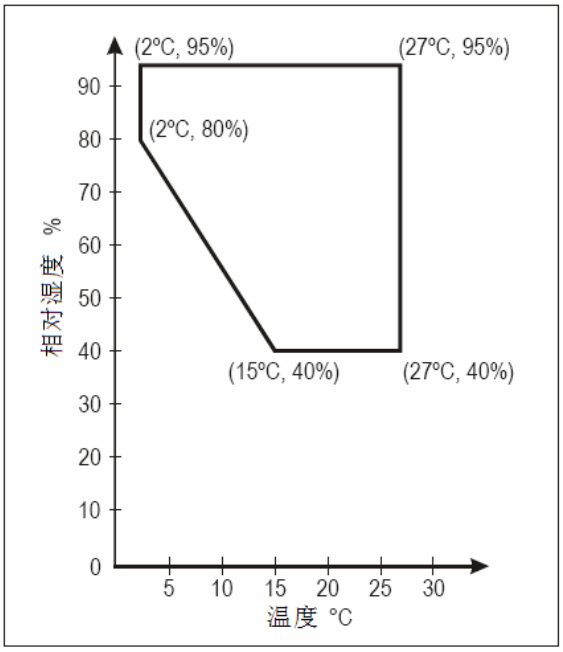


Figure 16: MEASUREMENT WINDOW FOR NO ABSORPTION CORRECTION (Figure G1 of regulation)

a. Explanation

Corrections are required to account for situations where the test atmospheric conditions are not the same as the reference conditions. There are two methods of making adjustments for absorption of sound in air, depending on the conditions. If the temperature and relative humidity are within the "no-correction" window shown in Figure G1 of the regulation, the adjustment is incorporated with the distance adjustment described in section G36.201(d)(2), below. If the temperature and relative humidity are outside the specified no-correction window, then a separate adjustment is required for atmospheric absorption.

b. Supplemental Information

(1) Regulatory Inconsistencies: The information included in the regulation has an inconsistency. Figure 16 shows that the low temperature limit of the no-correction window is at 35.6°F. The low temperature limit for testing is 36°F, only 0.4° higher.

(2) A second inconsistency was removed during harmonization. Before harmonization, (Section G36.201(b)) specified that the noise data were to be corrected to an atmospheric condition of 25°C (77°F). Reference airplane performance is obtained for an air temperature of 15°C (59°F). This inconsistency between the acoustic and airplane performance reference

conditions was corrected by adapting 15°C (59°F) for both reference conditions.

c. Procedures

None

409. Section G36.201(c)

No corrections for helical tip Mach number variation need to 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.

a. Explanation

None

b. Supplemental Information

None

c. Procedures

None

410. Section G36.201(d)

When the test conditions are outside those specified, corrections must be applied by an approved procedure or by the following simplified procedure:

a. Explanation

This adjustment is required when the ambient temperature and relative humidity combination is outside the no-correction window. It accounts for non-reference atmospheric absorption of sound when tests are conducted at conditions other than those within the allowed window.

b. Supplemental Information

None

c. Procedures

None

411. Section G36.201(d)(1)

Measured sound levels must be corrected from test day meteorological conditions to reference conditions by adding an increment equal to

$$\Delta(M) = (H_T\,\alpha - 0.7H_R)/1000$$

where H_T is the height in feet under test conditions, H_R is the height in feet under reference conditions when the aircraft is directly over the noise measurement point and α is the rate of absorption for the test day conditions at 500 Hz as specified in SAE ARP 866A, entitled "Standard Values of Atmospheric Absorption as a function of Temperature and Humidity for use in Evaluating Aircraft Flyover Noise" as incorporated by reference under §36.6.

a. Explanation

Δ(M), in decibels, is a correction for the difference in atmospheric absorption of sound between the test meteorological conditions and the acoustical reference conditions of 59°F and 70 percent Relative Humidity (RH). The applicant may use the simplified procedure provided in the regulation or may propose another procedure, which will require CAAC approval.

b. Supplemental Information

None

c. Procedure

(1) Atmospheric correction of the measured sound level data is necessary only if the meteorological conditions of temperature and relative humidity are outside specified in Figure G1 of Part 36, reproduced as Figure 16 in this AC.

Conditions that would be outside the measurement window include:

(i) Temperatures in excess of 27°C (80.6°F)

(ii) Relative humidities below 40 percent or above 95 percent

(iii) Relative humidities between 80 percent and 95 percent for temperatures below 2°C (35.6°F)

(iv) Combinations of temperature and Relative Humidity with values below the line in Figure 16 that connects 80 percent Relative Humidity, 2°C (35.6°F)

and 40 percent Relative Humidity, 15°C (59°F).

In general the correction, Δ(M), is to correct for differences in sound absorption in air at different combinations of temperature and relative humidity. The correction is given by:

$$\Delta(M) = (H_{T\alpha} - 0.7\ H_R)/1000$$

where H_T is the height (in feet) of the airplane over the noise measurement point during the actual test flight when the sound level was measured, and a is the rate of sound absorption per 1,000 feet at a frequency of 500 Hz, for the test-day temperature and humidity, as specified in the Society of Automotive Engineers (SAE) Aerospace Recommended Practice (ARP) 866A, entitled "Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity." The value of a at various combinations of temperature and relative humidity can be obtained from Figure 10 of ARP 866A or from tabulations contained in Table 2 of ARP 866A, which are accurate to the first decimal place, reproduced herein as Table 5 in the AC. For test humidities other than 70 percent, ARP 866A should be used.

Table 5: Rate of Atmospheric Absorption (a) at 500 Hz Frequency

Temp: AIR TEMPERATURE, ºF
α: ATMOSPHERIC ABSORPTION COEFFICIENT, dB/1000FT
500 Hz GEOMETRIC MEAN FREQUENCY

Temp	α	Temp	α	Temp	α	Temp	α	Temp	α
1	1.8	21	0.9	41	0.6	61	0.7	81	0.9
2	1.8	22	0.9	42	0.6	62	0.7	82	0.9
3	1.7	23	0.8	43	0.6	63	0.8	83	0.9
4	1.7	24	0.8	44	0.6	64	0.8	84	0.9
5	1.6	25	0.8	45	0.6	65	0.8	85	1.0
6	1.6	26	0.8	46	0.6	66	0.8	86	1.0
7	1.5	27	0.7	47	0.6	67	0.8	87	1.0
8	1.5	28	0.7	48	0.6	68	0.8	88	1.0
9	1.4	29	0.7	49	0.7	69	0.8	89	1.0
10	1.4	30	0.7	50	0.7	70	0.8	90	1.0
11	1.3	31	0.7	51	0.7	71	0.8	91	1.0
12	1.3	32	0.6	52	0.7	72	0.8	92	1.0
13	1.2	33	0.6	53	0.7	73	0.8	93	1.0
14	1.2	34	0.6	54	0.7	74	0.9	94	1.1
15	1.1	35	0.6	55	0.7	75	0.9	95	1.1
16	1.1	36	0.6	56	0.7	76	0.9	96	1.1
17	1.1	37	0.6	57	0.7	77	0.9	97	1.1

18	1.0	38	0.6	58	0.7	78	0.9	98	1.1
19	1.0	39	0.6	59	0.7	79	0.9	99	1.1
20	0.9	40	0.6	60	0.7	80	0.9	100	1.1

412. Section G36.201(d)(2)

Measured sound levels in decibels must be corrected for height by algebraically adding an increment equal to Δ(1). When test day conditions are within those specified in figure G1:

$$\Delta(1) = 221og(H_T/H_R)$$

where H_T is the height of the test aircraft when directly over the noise measurement point and H_R is the reference height.

When test day conditions are outside those specified in figure G1:

$$\Delta(1) = 201og(H_T/H_R)$$

a. Explanation

This adjustment is based on the test height relative to the reference height. Different procedures are specified, depending on whether the test was conducted in or out of the no-correction window identified in paragraph 408, above.

b. Supplemental Information

Inverse Square Correction: The adjustment accounts for the inverse square spreading of the sound during propagation. The adjustment is based on the noise certification test height and the reference height over the microphone. Different regulatory corrections are specified, depending on whether the test was conducted in or out of the no-correction atmospheric window.

c. Procedure

(1) Determine the height, temperature, and relative humidity at the surface for each data point and compute the appropriate adjustment.

413. Section G36.201(d)(3)

Measured sound levels in decibels must be corrected for helical tip Mach number by algebraically adding an increment equal to:

$$\Delta(2) = K2\ log(M_R/M_T)$$

where M_T and M_R are the test and reference helical tip Mach numbers,

respectively. The constant "K_2" is equal to the slope of the line obtained for measured values of the sound level in dB(A) versus helical tip Mach number. The value of K_2 may be determined from approved data. A nominal value of K_2 = 150 may be used when M_T is smaller than M_R. No correction may be made using the nominal value of K_2 when M_T is larger than M_R. The reference helical tip Mach number M_R is the Mach number corresponding to the reference conditions (RPM, airspeed, temperature) above the measurement point.

a. Explanation

This section specifies the adjustments to be made to account for non-reference propeller helical tip Mach number.

b. Supplemental Information

(1) Fixed-pitch Propeller Correction: This adjustment is not required for a fixed-pitch propeller if the engine power within 5 percent of the reference. If the test engine power is not within 5 percent the reference engine power, an approved correction is to be made.

(2) Correction Coefficient k: The format of the relationship between noise level and propeller helical tip Mach number has been developed from theoretical studies and tests. The rate at which the noise changes with Mach number is defined by the coefficient k. This has been found to vary for different installations and operating ranges.

(3) Correction Procedures: There are two alternative adjustment procedures for test Mach numbers less than reference. The regulation allows the use of an adjustment formula with k = 150 when the test helical tip Mach number (M_T) is less than the reference helical tip Mach number (MR). When M_T is greater than M_R, k = 150 is not to be used. For most propellers, the value of k is less than 150, so this may overestimate the adjustment, resulting in a noise level greater than it would be at reference conditions. If this possible overestimation is not acceptable or desirable, approved data may be used to determine k. Possible sources of approved data are supplementary tests in which the Mach number is varied over a sufficient range to obtain a value of k.

Section 4.1 of the ICAO Technical Manual (reference 3.j) provides guidance on deriving the noise-versus-tip-Mach-number relationship.

(4) Correction Options: There are two alternatives if the test Mach number is greater than reference. One option is not to make any adjustment, thus

ensuring that the noise level is not underestimated. The second option is to develop approved data, as discussed above, and use the value of k determined in this way.

(5) Correction Calculations: Calculation of the helical tip Mach number requires several steps. The propeller tip speed has two components.

(i) The speed at which the propeller tip is rotating (e.g., in ft/sec), denoted V_{tip}

(ii) The forward speed of the airplane (in similar units, e.g., ft/sec), denoted V_{tas}

The respective Mach numbers for actual test and reference conditions are therefore calculated from:

$$V_{hel} = \sqrt{V_{tip}^2 + V_{tas}^2}$$

$$M_{hel} = \frac{V_{hel}}{c}$$

The speed of sound in air at the test altitude (also similar units, e.g., ft/sec), denoted c.

where V_{hel} is the helical tip speed of the propeller and M_{hel} is the helical tip Mach number of the propeller. Calculation of Vtip, Vtas, and c for the appropriate conditions is as follows:

$$V_{tip} = rpm \times D \times \pi / 60, \text{ ft/sec}$$

where rpm is that of the propeller, D is the propeller diameter in feet, and π = 3.14159

$$V_{tas} = \frac{V_{cas}}{\sqrt{\sigma}}$$

where V_{cas} is airplane calibrated air speed multiplied by 1 to convert from knots to ft/sec.

$$\sigma = \frac{\Delta}{\theta}$$

where Pressure Ratio

$$\Delta = 1 - \left(6.8753^{-6} h\right)^{5.2561}$$

Temperature Ratio

$$\theta = \frac{T + 459.67}{59 + 459.67}$$

where temperature is in degrees Fahrenheit.

The speed of sound c is to be calculated for the appropriate temperature conditions during the test and for the reference condition of 59°F (15°C). The value of c for reference condition calculations can be obtained from

c = , ft/sec at sea level for T = 59°F - h × lapse rate (0.003566°F per foot)

where h (ft) is the airplane height above mean sea level (MSL) and atmospheric conditions (temperature versus altitude) conform to a standard atmosphere.

$M_R = V_{hel}/c$ reference height

$M_T = V_{hel}/c$ test height

c. Procedure

(1) Applicant's Responsibility: Determine the propeller helical tip Mach number for each noise certification test overflight condition and the reference condition. When required, make the appropriate adjustment to the noise levels to account for the off-reference helical tip Mach number.

414. Section G36.201(d)(4)

Measured sound levels in decibels must be corrected for engine power by algebraically adding an increment equal to

$$\Delta(3) = K_3 \, 1og(P_R/P_T)$$

where P_R and P_T are the test and reference engine powers respectively obtained from the manifold pressure/torque gauges and engine RPM. The value of K_3 shall be determined from approved data from the test airplane. In the absence of flight test data and at the discretion of the Administrator, a value of $K_3 = 17$ may be used.

a. Explanation

This section provides the adjustments for non-reference engine power.

In the engine power correction equation, denoted by Δ(3), P_R is the reference engine power setting at H_R (airplane over measurement point, calculated for reference flight path), and P_T is the actual test power during overflight of the microphone location. These powers are to be determined by referring to the information manual for the engine-propeller configuration and may be assessed from the engine rpm, engine manifold pressure, or other installed instrumentation appropriate to the airplane being tested, at the altitude above mean sea level.

The reference power (P_R) will be the maximum continuous installed power for a V_y (best rate of climb) take-off at sea level conditions and standard atmospheric conditions (1013.25 mb, 59°F) adjusted for reference altitude and at 70 percent Relative Humidity. This may be found from the airplane manufacturer's supplied data. If the manufacturer's data are not available, density ratio for altitude pressure and lapse rate for ambient temperature (59°F – lapse rate × HR, lapse rate = 0.003566°F per foot) calculations can be used.

The actual test power (P_T) should be appropriate to the pressure altitude and ambient temperature of the test conditions. Typically, the field elevation plus 1,000 feet can be used to estimate the loss of engine power. Again, these data should be available in manufacturer's supplied information for the specific airplane. However, where such information is not available, a correction should be applied to the manufacturer's published engine power (normally presented for a range of engine speeds under International Standard Atmosphere (ISA) and sea level conditions) to establish the engine power level under the test conditions, as follows:

for normally aspirated engines,

$$P_T = P_K\left[\left(\frac{T_K}{T_T}\right)^{\frac{1}{2}}\right]\left[\frac{\sigma - 0.117}{0.883}\right]$$

and for turbocharged engines,

$$P_T = P_K\left[\left(\frac{T_K}{T_T}\right)^{\frac{1}{2}}\right]$$

Where P_T and P_K are the test and known engine powers, T_K and T_T are the test and known ambient temperatures, and s is the air density ratio.

Power correction factor K_3 can be determined by running a series of tests to obtain noise levels (dB(A)) versus engine power. In cases in which it is not practical to vary engine power independent of engine rpm (such as for fixed-pitch propellers) the power and helical tip Mach number can be obtained from one series of tests and applied to the data.

Section 4.1 of the ICAO Technical Manual (reference 3.j) has guidance on deriving the noise versus tip Mach number and noise versus engine power relationships.

b. Supplemental Information

(1) Fixed-pitch Propellers: This adjustment is not required if the fixed-pitch propeller engine power for the test condition is within 5 percent of the reference engine power.

(2) Maximum Continuous Power for Airplanes with Variable-Pitch Propellers: Airplanes with variable-pitch propellers, in addition to the throttle, have a cockpit control that allows the pilot to control the propeller rotational speed (rpm). Once set, a governor maintains a constant rpm, as long as conditions are within the control range of the governor. In some instances, the engine characteristics are such that the use of take-off power is limited to a specified maximum time (e.g., 5 minutes). Maximum continuous power is less than take-off power, and reducing the engine power setting and/or the propeller rpm sets the lower power. Maximum continuous power settings that are used during the climb portion of the noise certification testing are displayed to the pilot in the form of instrument markings. These markings are in the form of green arcs for ranges where there are no time or other limitations. For piston-engine-powered airplanes, the limiting rpm is usually stated in terms of engine rpm, so with geared propellers the propeller rpm can be determined directly from the gear ratio. The engine power setting parameter, controlled by the throttle, may be the manifold pressure, that is the absolute pressure in the manifold that supplies air to the cylinders. For turboprop installations, there is usually a direct control for the propeller rpm, although it may have only two speeds and may not be infinitely variable. The power setting parameter may be in several different forms, such as propeller (or other) shaft torque, or the temperature of the burned air-fuel mixture at the turbine inlet (TIT).

(3) Maximum Continuous Power for Airplanes with Fixed-Pitch Propellers: Many small airplanes are designed to use a fixed-pitch propeller. With these airplanes, the pilot has only a throttle control with no separate control of

propeller pitch. The rpm is dependent on the flight regime and throttle setting. At maximum throttle, as used for take-off and climb conditions, the rpm is appreciably less than maximum, and the engine does not develop its rated power. There is a small increase in rpm as the airplane accelerates on the runway to inflight airspeed, but the rpm is still appreciably below the maximum. Maximum engine rpm cannot be achieved until the airplane is in the cruise phase of flight. The engine power that is achieved during the climb portion of the flight is to be considered the reference power for noise certification purposes and may be dependent on the airport altitude (ambient pressure), temperature, and relative humidity. The airplane manufacturer's data can provide reference power information.

(4) Determination of Power for Piston Engines: Engine manufacturers provide charts that can be used to determine the power developed by the engine under various operating conditions. The variables that control engine power are rpm, manifold pressure, density altitude, and ambient air temperature. These charts usually apply to a test-bench situation, with no power losses due to power extraction (alternators, pumps, etc.) and with an air intake and exhaust system designed for test-bench use. In practice, using the un-installed power for both test and reference conditions will provide satisfactory results, when CAAC approved.

c. Procedure

(1) Engine Power Adjustment: Determine the engine powers for each test overflight condition and use an approved procedure to adjust the measured noise levels to reference conditions.

415. Section G36.203 Validity of Results

(a) The measuring point must be overflown at least six times. The test results must produce an average noise level (L_{Amax}) value within a 90 percent confidence limit. The average noise level is the arithmetic average of the corrected acoustical measurements for all valid test runs over the measuring point.

(b) The samples must be large enough to establish statistically a 90 percent confidence limit not exceeding ±1.5 dB(A). No test results may be omitted from the averaging process unless omission is approved by the CAAC.

a. Explanation

At least six test data points must be obtained in order to satisfy this regulatory section. The certification noise level is then determined from the arithmetic average of these noise levels. All valid data points are to be included in the average. A statistical test is applied to ensure that the average has been adequately determined. The 90 percent confidence limit, computed using established statistical methods, may not exceed ± 1.5 dB (A).

b. Supplemental Information

(1) Valid Data: Test points may not be excluded without the approval of the FAA. Exclusions will not be approved unless there is a valid technical reason. Arbitrary exclusion of a test point on the basis of its measured level is not permitted.

(2) Confidence Limit Exceedance: If the 90 percent confidence limit does not satisfy the ± 1.5 dB (A) requirement, the only recourse is to obtain additional test data points, increasing the number of events until the confidence limit is reduced to ± 1.5 dB (A). The variability of data obtained under controlled conditions should be substantially less than ± 1.5 dB. If the 90 percent confidence interval is near or above the permitted limit, the approved test procedures and/or correction procedures should be carefully reviewed.

c. Procedures

(1) Average Noise Level Calculations: Calculation of the average noise is accomplished by summing the adjusted noise levels of the data points and dividing by the number of values in the sample. This can be written as:

$$(L_{A\max})_{avg} = \frac{1}{N}\sum_{i=1}^{n} L_{A\max(i)} = \frac{1}{N}\left[L_{A\max(1)} + L_{A\max(2)} + \cdots + L_{A\max(n)}\right]$$

where $L_{Amax(i)}$ is the corrected noise level of the ith, test flight and N is the total number of test results in the calculation of the average. When the 90 percent confidence limit calculated using data from six or more test flights is within ± 1.5 dB (A), then the average corrected noise level $(L_{Amax})_{avg}$ resulting from the validated data can be used to determine conformity with the Appendix G Noise Levels, as described in section G36.301.

(2) Confidence Level Calculations: Other statistical terms are used to quantify the scatter of the values around the average value and the range (above and below the average value) that a test result should fall within, with a stated confidence. These terms are known respectively as:

(i) The standard deviation of the results

(ii) The confidence limits (in our case, ± 1.5 dB (A)) that are a range above and below the average value for a stated confidence (in our case, 90 percent probability).

The requirement on the confidence limits (of the corrected noise level data) is based on a statistical test involving the number of test results (N) and the standard deviation(s) of the test noise levels.

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(L_{A\max(i)} - (L_{A\max})_{avg}\right)^2} = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}$$

where

$x_i = L_{A\max(i)}$ = the corrected noise level, in dB (A) of the ith valid test flight

$\bar{x} = (L_{A\max})_{avg}$ = the average of the corrected noise levels, as described earlier in this section.

After calculating the standard deviation(s), the 90 percent confidence interval can be calculated using the equation:

$$CI = \pm t\frac{S}{\sqrt{N}}$$

where t = Student's t distribution for 90 percent confidence interval and V degrees of freedom (from Table 6), N = number of data points, V = degrees of freedom = N – 1.

Table 6: Student's t Distribution For 90 Percent Confidence Interval

Degree of Freedom (V)	Student's *t* Distribution for 90 percent Confidence Interval
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812

12	1.782
14	1.761
16	1.746
18	1.734
20	1.725
24	1.711
30	1.697
60	1.671
∞	1.645

416. PART D - NOISE LIMITS

417. Section G36.301 Aircraft Noise Limits

(a) Compliance with this section must be shown with noise data measured and corrected as prescribed in Parts B and C of this appendix.

(b) For single-engine airplanes for which the original type certification application is received before April 15, 2007 and multi-engine airplanes, the noise level must not exceed 76 dB(A) up to and including aircraft weights of 600 kg (1,320 pounds). For aircraft weights greater than 600 kg (1,320 pounds), the limit increases from that point with the logarithm of airplane weight at the rate of 9.83 dB (A) per doubling of weight, until the limit of 88 dB (A) is reached, after which the limit is constant up to and including 8,618 kg (19,000 pounds). Figure G2 shows noise level limits vs airplane weight.

(c) For single-engine airplanes for which the original type certification application is received on or after April 15, 2007, the noise level must not exceed 70 dB(A) for aircraft having a maximum certificated takeoff weight of 570 kg (1,257 pounds) or less. For aircraft weights greater than 570 kg (1,257 pounds), the noise limit increases from that point with the logarithm of airplane weight at the rate of 10.75 dB(A) per doubling of weight, until the limit of 85 dB(A) is reached, after which the limit is constant up to and including 8,618 kg (19,000 pounds). Figure G2 depicts noise level limits for airplane weights for single-engine airplanes.

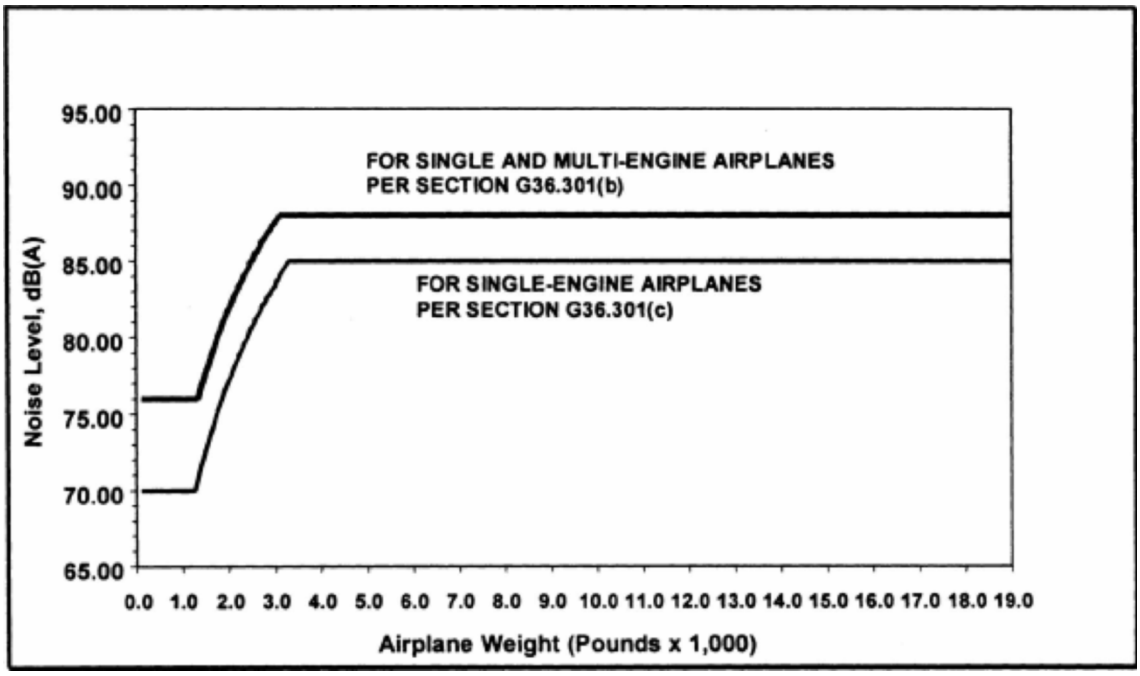


Figure 17 - Noise Level vs. Airplane Weight (Figure G2 of part 36, Appendix G)

a. Explanation

The noise level limit varies depending on the maximum certificated take-off gross weight according to the specified formula, as depicted in Figure 17.

b. Supplemental Information

(1) Noise Level Limits specified in section G36.301(b): As followed.

M = Maximum take-off mass in 1 000 kg	0	0.6	1.4	8.618
Noise level in dB(A)	76	83.23 + 32.67 log M	88	

If using Imperial units,

W = Maximum take-off eught in pounds	0	1320	3086	19000
Noise level in dB(A)	76	32.67 log W – 26.0	88	

(2) Noise Level Limits specified in section G36.301(c):

M = Maximum take-off mass in 1 000 kg	0	0.57	1.5	8.618
Noise level in dB(A)	76	78.71＋35.70logM	88	

c. Procedure

(1) Limit Comparison: The noise level limit is computed based on the maximum take-off gross weight and compared with the average measured (and corrected) noise level in terms of dB (A).

418. -429. [RESERVED]

XVI. Appendix H — NOISE REQUIREMENTS FOR HELICOPTERS UNDER SUBPART H [To be completed later]

XVII. Appendix J — Alternative Noise Certification Procedure for Helicopters Under Subpart H Having a Maximum Certificated Takeoff Weight of Not More Than 7,000 Pounds [To be completed later]

Aircraft Airworthiness Certification Department
of Civil Aviation Administration of China
(CAAC-AAD)

Advisory Circular

No. : AC-36-AA-2008-04
Date: 3/17/2008

NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION

（APPENDICES）

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APPENDIX I – ENVIRONMENTAL TECHNICAL MANUAL ON THE USE OF PROCEDURES IN THE NOISE CERTIFICATION OF AIRCRAFT

This Steering Group approved revision includes material which has been approved by the relevant Working Groups of the ICAO Committee on Aviation Environmental Protection (CAEP). Its purpose is to make available new information to certificating authorities, noise certification applicants and other interested parties as soon as it has been agreed by the working groups, therefore eliminating the delay which would otherwise occur should its publication be limited only to post CAEP meetings. Prior to these meetings the then current approved revision will be reviewed for submission to CAEP for formal endorsement and subsequent publication by ICAO.

NOMENCLATURE

Symbols and abbreviations employed in this manual are consistent with those contained in ICAO Annex 16, Volume 1, Third Edition, July 1993.

Symbol	Unit	Description
c	m/s	Speed of sound
CI	dB	90 per cent Confidence interval in decibel units relevant to the calculation being made.
D	m	Jet nozzle diameter based on total nozzle exit area.
EPNL	EPNdB	Effective Perceived Noise Level
F	N	Engine net thrust
f	Hz	1/3-octave band centre frequency
ICD	-	Inflow control device
K	-	Constant
L	dBA	'A' - weighted sound pressure level
M	-	Mach number
M_H	-	Propeller helical tip Mach number
MAP	in. Hg	Manifold air pressure
N_P	rpm	Propeller rotational speed
N_1	rpm	Low pressure rotor speed of turbine engines
OASPL	dB	Overall Sound Pressure Level
PNL	PNdB	Perceived Noise Level
PNLT	TPNdB	Tone Corrected Perceived Noise Level
PNLTM	TPNdB	Maximum Tone Corrected Perceived Noise Level
S	-	Strouhal number (fD/V_j)
SHP	kW	Shaft horse power
SPL	dB	Sound pressure level based on a reference of 20 μPa
TCL	ºC	Air temperature at engine centreline height
TMIC	ºC	Air temperature at the ground plane microphone height
V_j	m/sec	Jet velocity for complete isentropic expansion to ambient pressure
V	m/sec	Aircraft airspeed
Vy	m/sec	Aircraft best rate of climb speed
WCL	Km/h	Average wind speed at engine centreline height
x	m	Distance downstream from nozzle exit
δ_{amb}	-	Ratio of absolute static pressure of the ambient air at the height of the aeroplane to ISA air pressure at mean sea level (i.e. 101.325 kPa)
θ_{t2}		Ratio of absolute static temperature of the air at the height of the aeroplane to the absolute temperature of the air at sea level for ISA

		conditions (i.e. 288.15 ºK)
μ	-	Engine power related parameter, or mean value see Appendix 1
λ	degrees	Angle between the flight path in the direction of flight and a straight line connecting the aeroplane and the microphone at the time of sound emission
σ	-	Ratio of atmospheric air density at altitude to that at sea level for ISA conditions

Suffices

flt Quantity related to flight conditions

max Maximum value

ref Quantity related to reference conditions

static Quantity related to static conditions

test Quantity related to test conditions

DOP Doppler related quantity

Abbreviations

ESDU Engineering Sciences Data Unit

ISA International Standard Atmosphere

NPD Noise-power-distance

SAE AIR Society of Automotive Engineers - Aerospace Information Report

SAE ARP Society of Automotive Engineers - Aerospace Recommended Practice

Notes: Where log is used in this document it denotes logarithm to the base of 10.

SECTION 1 - GENERAL

1.1 PURPOSE

1.1.1 The aim of this manual is to promote uniformity of implementation of the technical procedures of Annex 16, Volume 1, and to provide guidance such that all certificating authorities can apply the same degree of stringency and the same criteria for acceptance in approving applications for the use of equivalent procedures.

1.1.2 This manual provides guidance in the wider application of equivalent procedures that have been accepted as a technical means for demonstrating compliance with the noise certification requirements of Annex 16, Volume 1. Such procedures are referred to in Annex 16, Volume 1, but are not dealt with in the same detail as in the Appendices to the Annex which describe the noise evaluation methods for compliance with the relevant Chapters.

1.1.3 Annex 16, Volume 1, procedures must be used unless an equivalent procedure is approved by the certificating authority. Equivalent procedures should not be considered as limited only to those described herein, as this manual will be expanded as new procedures are developed.

1.1.4 For the purposes of this manual an equivalent procedure is a test or analysis procedure which, while differing from one specified in Annex 16, Volume 1, in the technical judgement of the certificating authority, yields effectively the same noise levels as the specified procedure.

1.1.5 References to Annex 16, Volume 1, relate to the Amendment 6 thereof.

1.2 FRAMEWORK

Equivalent procedures fall into two broad categories; those which are generally applicable and those which are applicable to a particular aircraft type. For example, some equivalencies dealing with measurement equipment may be used for all types of aircraft, but a given test procedure may only be appropriate for turbojet powered aeroplanes, and not to turboprop powered aeroplanes. Consequently this manual is framed to provide information on equivalent procedures applicable to the types of aircraft covered by Annex 16, Volume 1,

i.e. jet powered, propeller driven heavy and light aeroplanes and helicopters. Equivalent procedures applicable to each aircraft type are identified in separate sections. Each section covers, in the main, flight test equivalencies, the use of analytical procedures and equivalencies in evaluation procedures.

1.3 INCORPORATION OF EQUIVALENT PROCEDURES INTO THE NOISE COMPLIANCE DEMONSTRATION PLAN

1.3.1 Prior to undertaking a noise certification demonstration, the applicant is normally required to submit to the certificating authority a noise compliance demonstration plan. This plan contains the method by which the applicant proposes to show compliance with the noise certification requirements. Approval of this plan and the proposed use of any equivalent procedure remains with the certificating authority. The procedures in this manual are grouped for specific applications. The determination of equivalency for any procedure or group of procedures must be based upon the consideration of all pertinent facts relating to the application for a certificate.

1.3.2 Use of equivalent procedures may be requested by certificate applicants for many reasons, such as:

a) to make use of previously acquired certification test data for the aeroplane type;

b) to permit and encourage more reliable demonstration of small noise level differences among derived versions of an aeroplane type; and

c) to minimise the costs of demonstrating compliance with the requirements of Annex 16, Volume 1, by keeping aircraft test time, airfield usage, and equipment and personnel costs to a minimum.

1.3.3 The material included in this manual is for technical guidance only. The use of past examples of approved equivalencies does not imply that these equivalencies are the only acceptable ones, neither does their presentation imply any form of limitation of their application, nor does it imply commitment to further use of these equivalencies.

1.4 CHANGES TO THE NOISE CERTIFICATION LEVELS FOR DERIVED VERSIONS

1.4.1 Many of the equivalent procedures given in this manual relate to derived versions, where the procedure used yields the information needed to

obtain the noise certification levels of the derived version by adjustment of the noise levels of the "flight datum" aircraft (i.e. the most appropriate aircraft for which the noise levels were measured during an approved Annex 16, Volume 1, flight test demonstration).

1.4.2 The physical differences between the "flight datum" aircraft and the derived version can take many forms, for example, an increased take-off weight, an increased engine thrust, changes to the powerplant or propeller or rotor types, etc. Some of these will alter the distance between the aircraft and the noise certification reference points, others the noise source characteristics. Procedures used in the determination of the noise certification levels of the derived versions will therefore depend upon the change to the aircraft being considered. However, where several similar changes are being made, for example, introduction of engines from different manufacturers, the procedures used to obtain the noise certification levels of each derivative aircraft should be followed in identical fashion.

1.4.3 Aircraft/engine model design changes and airframe/ engine performance changes may result in very small changes in aircraft noise levels that are not acoustically significant. These are referred to as noacoustical changes. For this manual, noacoustical changes, which do not result in modification of an aircraft’s certificated noise levels, are defined as:

a) Changes in aircraft noise levels approved by certificating authorities as not exceeding 0.1 dB at any noise measurement point and which an applicant does not track;

b) Cumulative changes in aircraft noise levels approved by certificating authorities whose sum is greater than 0.1 dB but not more than 0.3 dB at any noise measurement point and for which an applicant has an approved tracking procedure.

1.4.4 Noise certification approval has been given for a tracking procedure of the type identified in 1.4.3b, based upon the following criteria:

a) Certification applicant ownership of the noise certification database and tracking process based upon an aircraft/engine model basis;

b) When 0.3 dB cumulative is exceeded, compliance with Annex 16 Volume 1 requirements is required. The aircraft certification noise levels may not be based upon summation of noacoustical change noise increments;

c) Noise level decreases should not be included in the tracking process

unless the type design change will be retrofitted to all aircraft in service and included on newly produced aircraft;

d) Aircraft/engine design changes resulting in noise level increases should be included in the tracking process regardless of the extent of retrofit to aircraft in service;

e) Tracking of an aircraft /engine model should, in addition to engine design changes, include airframe, and performance changes;

f) Tracked noise increments should be determined on the basis of the most noise sensitive condition and be applied to all configurations of the aircraft/engine model;

g) The tracking should be revised to account for a tracked design change increment that is no longer applicable;

h) Changes should be tracked to two decimal places (e.g. 0.01dB). Roundoff shall not be considered in judging a no-acoustical change (e.g. 0.29dB = no-acoustical change ; 0.30dB = noacoustical change ; 0.31dB = acoustical change);

i) An applicant should maintain formal documentation of all no-acoustical changes approved under a tracking process for an airframe/engine model. The tracking list will be reproduced in each noise certification dossier demonstration; and

j) Due to applicable dates for Chapters concerning helicopters and light propeller driven aeroplanes, some aircraft are not required to have certified noise levels. However some modifications to these aircraft can be applied which may impact the noise characteristics. In which case the noacoustical criterion application will be treated with a procedure approved by the certificating authority.

1.5 RE-CERTIFICATION

1.5.1 Re-certification is defined as the “Certification of an aircraft with or without revision to noise levels, to a Standard different to that which it had been originally certified”.

1.5.2 In the case of an aircraft being recertificated from the standards of ICAO Annex 16, Volume 1, Chapter 3 to a more stringent standard that may be directly applicable to new types only, noise re-certification should be granted on

the basis that the evidence used to determine compliance is as satisfactory as the evidence associated with a new type design. The date used by a certificating authority to determine the re-certification basis should be the date of acceptance of the first application for re-certification.

1.5.3 The basis upon which the evidence associated with applications for re-certification described in paragraph 1.5.2 should be assessed is presented in Appendix 8.

SECTION 2 - EQUIVALENT PROCEDURES FOR SUBSONIC JET POWERED AEROPLANES

The objective of a noise demonstration test is to acquire data for establishing an accurate and reliable definition of the aeroplane's noise characteristics under reference conditions (see Section 2.6 of Annex 16, Volume 1, for Chapter 2 aeroplanes and Section 3.6 for Chapter 3 aeroplanes). In addition, the Annex sets forth a range of test conditions and the procedures for adjusting measured data to reference conditions.

2.1 FLIGHT TEST PROCEDURES

The following methods have been used to provide equivalent results to Annex 16, Volume 1, Chapters 2 and 3 procedures for turbo-jet and turbo-fan powered aeroplanes.

2.1.1 Flight path intercept procedures

2.1.1.1 Flight path intercept procedures in lieu of full take-off and/or landing profiles described in paragraphs 9.2 and 9.3 of Appendix 1 or paragraphs 9.2 of Appendix 2 of Annex 16, Volume 1, have been used to meet the demonstration requirements of noise certification. The intercept procedures have also been used in the implementation of the generalised flight test procedures described in Section 2.1.2 of this manual. The use of intercepts eliminates the need for actual take-offs and landings (with significant cost and operational advantages at high gross mass) and substantially reduces the test time required. Site selection problems are reduced and the shorter test period provides a higher probability of stable meteorological conditions during testing. Aeroplane wear, and fuel consumption are reduced and increased consistency and quality in noise data are obtained.

2.1.1.2 Figure l(a) illustrates a typical take-off profile. The aeroplane is initially stabilised in level flight at a point A and continues to point B where take-off power is selected and a steady climb is initiated. The steady climb condition is achieved at point C, intercepting the reference take-off flight path and continuing to the end of the noise certification take-off flight path. Point D is the theoretical take-off rotation point used in establishing the reference flight path. If cutback power is employed, point E is the point of application of power

cutback and F, the end of the noise certification take-off flight path. The distance TN is the distance over which the position of the aeroplane is measured and synchronised with the noise measurement at K.

2.1.1.3 For approach, the aeroplane usually follows the planned flight trajectory while maintaining a constant configuration and power until no influence on the noise levels within ten decibels of PNLTM. The aeroplane then carries out a go-around rather than continuing the landing (See Fig. 1(b)).

2.1.1.4 For the development of the noise-power-distance data for the approach case (see 2.1.2.1) the speed, and approach angle constraints imposed by Annex 16, Volume 1 in 2.6.2 and 3.6.3 and 3.7.5 cannot be satisfied over the typical ranges of thrust needed. For the approach case speed shall be maintained at 1.3 V_S + 19 km/h (1.3 V_S + 10 kt) to within ±9 km/h or ±5 kt and flyover height over the microphone maintained at 400 ft ±100 ft. However the approach angle at the test thrust shall be that which results from the aircraft conditions, ie. mass, configuration, speed and thrust.

2.1.1.5 The flight profiles should be consistent with the test requirements of the Annex over a distance that corresponds at least to noise levels 10 dB below the maximum tone corrected Perceived Noise Level (PNLTM) obtained at the measurement points during the demonstration.

2.1.2 Generalised flight test procedures

The following equivalent flight test procedures have been used for noise certification compliance demonstrations.

2.1.2.1 Derivation of noise, power, distance data

2.1.2.1.1 For a range of powers covering full take-off and cut-back powers, the aeroplane is flown past lateral and under-flight-path microphones according to either the take-off procedures defined in paragraph 3.6.2 of Volume 1 of Annex 16 or, more typically, flight path intercept procedures described in Section 2.1.1 of this manual. Target test conditions are established for each sound measurement. These target conditions define the flight procedure, aerodynamic configuration to be selected, aeroplane weight, power, airspeed and, at the closest point of approach to the measurement location, height. Regarding choice of target airspeeds and variation in test weights, the possible combinations of these test elements may affect the aeroplane angle-of-attack or aeroplane attitude and therefore possibly the aeroplane sound generation or propagation geometry. The aeroplane angle-of-attack will remain approximately

constant for all test weights if the tests are conducted at the take-off reference airspeed appropriate for each test weight. (As an example if the appropriate take-off reference airspeed for the aeroplane is V_2+15 kt set the target airspeed for each test weight at V_2+15 kt; the actual airspeed magnitude will vary according to each test weight but the aeroplane test angle-of-attack will remain approximately constant.) Alternatively, for many aeroplanes the aeroplane attitude remains approximately constant for all test weights if all tests are conducted at the magnitude of the take-off reference airspeed corresponding to the maximum take-off weight. (As an example if the approximate take-off reference airspeed for the aeroplane is V_2+15 kt set the target airspeed for each test weight at the magnitude of the V_2+15 kt airspeed that corresponds to the maximum take-off weight; the airspeed magnitude remains constant for each test weight and the aeroplane attitude remains approximately constant.) Review of these potential aeroplane sensitivities may dictate the choice of target airspeeds and/or test weights in the test plan in order to limit excessive changes in angle-of-attack or aeroplane attitude that could significantly change measured noise data. In the execution of each condition the pilot should “set up” the aeroplane in the appropriate condition in order to pass by the noise measurement location within the target height window, while maintaining target power and airspeed, within agreed tolerances, throughout the 10dB-down time period.

2.1.2.1.2 A sufficient number of noise measurements are made to enable noise-power curves at a given distance for both lateral and flyover cases to be established. These curves are extended either by calculation or by the use of additional flight test data to cover a range of distances to form the generalised noise data base for use in the noise certification of the "flight datum" and derived versions of the type and are often referred to as Noise-Power-Distance (NPD) plots (see Fig. 2). If over any portion of the range for the NPD plot the criteria for calculating the EPNdB given in paragraphs 9.1.2 and 9.1.3 of Appendix 2 of Annex 16, Volume 1, requires the use of the integrated procedure, this procedure shall be used for the whole NPD. The 90 per cent confidence intervals about the mean lines are constructed through the data (see paragraph 2.2 of Appendix 1).

Note: The same techniques can be used to develop NPD’s appropriate for the derivation of approach noise levels by flying over an under flight path microphone for a range of approach powers using the speed and aeroplane configuration given in paragraph 3.6.3 of Annex 16, Volume 1, or more typically, flight test procedures described in 2.1.1 of this manual.

2.1.2.1.3 Availability of flight test data for use in data adjustment, e.g. speed and altitude, should be considered in test planning and may limit the extent to which a derived version may be developed without further flight testing especially where the effects of airspeed on source noise levels become significant. The effects of high altitude test site location on jet noise source levels should also be considered in test planning. High altitude test site locations have been approved under conditions specified in Appendix 6 provided that jet noise source corrections are applied to the noise data. The correction method of Appendix 6 has been approved for this purpose.

2.1.2.1.4 The take-off, lateral and approach noise measurements should be corrected to the reference speed and atmospheric conditions over a range of distances in accordance with the procedures described in Appendix 1 (Chapter 2 aeroplanes) or Appendix 2 (Chapter 3 aeroplanes) of Annex 16, Volume 1. The NPD plots can then be constructed from the corrected Effective Perceived Noise Level (EPNL), power and distance information. The curves present the EPNL value for a range of distance and engine noise performance parameters, (see Annex 16, Volume 1, paragraph 9.3.4.1 of Appendix 2). The parameters are usually the corrected low pressure rotor speed $\frac{N_1}{\sqrt{\theta_{t_2}}}$ or the corrected net thrust $\frac{F_N}{\delta_{amb}}$ (see Fig. 2), where:

N_1 is the actual low pressure rotor speed;

$\sqrt{\theta_{t_2}}$ is the ratio of absolute static temperature of the air at the height of the aeroplane to the absolute temperature of the air for an international standard atmosphere (ISA) at mean sea level (ie. 288.15 °K);

F_N is the actual engine net thrust per engine; and

δ_{amb} is the ratio of absolute static pressure of the ambient air at the height of the aeroplane to ISA air pressure at mean sea level (ie. 101.325 kPa).

2.1.2.1.5 Generalised NPD data may be used in the certification of the flight tested aeroplane and derivative versions of the aeroplane type. For derived versions, these data may be used in conjunction with analytical procedures, static testing of the engine and nacelle or additional limited flight tests to demonstrate compliance.

2.1.2.2 Procedures for the determination of changes in noise levels

Noise level changes determined by comparison of flight test data for different developments of an aeroplane type have been used to establish certification noise levels of newly derived versions by reference to the noise

levels of the "flight datum" aeroplane. These noise changes are added to or subtracted from the noise levels obtained from individual flights of the "flight datum" aeroplane. Confidence intervals of new data are statistically combined with the "flight datum" data to develop overall confidence intervals (see Appendix 1).

2.1.3 The determination of the lateral noise certification levels

2.1.3.1 Alternative procedures using two microphone stations located symmetrically on either side of the takeoff reference track has proved to be effective in terms of time and costs savings. Such an arrangement avoids many of the difficulties encountered in using the more conventional multimicrophone arrays. The procedures consist of flying the test aeroplane at full take-off power at one (or more) specified heights above a track at right angles to and midway along the line joining the two microphone stations. However, when this procedure is used matching data from both lateral microphones for each fly-by should be used for the lateral noise determination; cases where data from only one microphone is available for a given run must be omitted from the determination. The following paragraphs describe the procedures for determining the lateral noise level for subsonic turbo-jet or turbofan powered aeroplanes.

2.1.3.2 Lateral noise measurements for a range of conventionally configured aeroplanes with under wing and/or rearfuselage mounted engines with bypass ratio of more than 2, have shown that the maximum lateral noise at full power normally occurs when the aeroplane is close to 300 m (985 ft) or 435 m* (1,427 ft) in height during the take-off. Based on this finding it is considered acceptable to use the following as an equivalent procedure:

a) for aeroplanes to be certificated under Chapter 3 or Chapter 2 of Annex 16, Volume 1, two microphone locations are used, symmetrically placed on either side of the aeroplane reference flight track and 450 m or 650 m* from it;

b) for aeroplanes with engines having bypass ratios of more than 2, the height of the aeroplane as it passes the microphone stations should be 300 m (985 ft) or 435 m* (1,427 ft) and be no more than +100 m, -50 m (+328 ft, -164 ft) relative to this target height. For aeroplanes with bypass ratios of 2 or less it is necessary to determine the peak lateral noise by undertaking a number of flights over a range of heights to define the noise (EPNL) versus height characteristics. A typical height range would cover 60 m (200 ft) to 600 m (2000 ft) above the inter-section of a track at right angles to the line joining the two

microphone positions and this line;

c) constant power, configuration and airspeed as described in paragraphs 3.6.2.1 a), 3.6.2.1 d), 2.6.1.2 and 2.6.1.3 of Annex 16, Volume 1, should be used during the flight demonstration;

d) adjustment of measured noise levels should be made to the acoustical reference day conditions and to reference aeroplane operating conditions as specified in Section 9 of Appendix 1 and 2 of Annex 16, Volume 1; and

e) to account for any possible asymmetry effects in measured noise levels, the reported lateral noise level for purposes of demonstrating compliance with the applicable noise limit of Chapter 3 or Chapter 2 of Annex 16, Volume 1, as applicable, should be the arithmetic average of the corrected maximum noise levels from each of the two lateral measurement points and compliance should be determined within the ±1.5 dB 90 per cent confidence interval required by the Annex (see paragraph 2 of Appendix 1 of this manual).

2.1.3.3 Lateral noise certification level determination has also been accomplished using multiple pairs of lateral microphones rather than only one pair of symmetrically located microphones. A sufficient number of acceptable data points, resulting from a minimum of six runs, must be obtained from sufficiently spaced microphone pairs to adequately define the maximum lateral noise certification level and provide an acceptable 90 per cent confidence interval.

2.1.4 Take-off flyover noise levels with power cut-back

Flyover noise levels with power cut-back may also be established without making measurements during take-off with full power followed by power reduction in accordance with paragraph 2.2.1 of this manual.

2.1.5 Measurements at non-reference points

2.1.5.1 In some instances test measurement points may differ from the reference measurement points specified in Annex 16, Volume 1, Chapters 2 and 3, paragraphs 2.3.1 and 3.3.1. Under these circumstances an applicant may request approval of data that have been adjusted from the actual measurements to represent data that would have been measured at the reference points in reference conditions.

2.1.5.2 Reasons for such a request may be:

a) to allow the use of a measurement location that is closer to the aeroplane

flight path so as to improve data quality by obtaining a greater ratio of signal to background noise. Whereas Appendix 3 describes a procedure for removing the effects of ambient noise the use of data collected closer to the aeroplane avoids the interpolations and extrapolations inherent in the method;

b) to enable the use of an existing, approved certification data base for an aeroplane type design in the certification of a derivative of that type when the derivative is to be certificated under reference conditions that differ from the original type certification reference conditions; and

c) to avoid obstructions near the noise measurement station(s) which could influence sound measurements. When a flight path intercept technique is being used, take-off and approach noise measurement stations may be relocated as necessary to avoid undesirable obstructions. Sideline measurement stations may be relocated by distances which are of the same order of magnitude as the aeroplane lateral deviations (or offsets) relative to the nominal flight paths that occur during flight testing.

2.1.5.3 Approval has been granted to applicants for the use of data from nonreference noise measurement points provided that measured data are adjusted to reference conditions in accordance with the requirements of section 9 of Appendix 1 or 2 of Annex 16, Volume 1, and the magnitudes of the adjustments do not exceed the limitations in section 5.4 of Appendix 1 and paragraph 3.7.6 of Chapter 3 of the Annex.

2.1.6 Atmospheric test conditions

It has been found acceptable by certificating authorities to exceed the sound attenuation limits of Annex 16, Volume 1, Appendix 2, Section 2.2.2(c) when:

a) the dew point and dry bulb temperature are measured with a device which is accurate to ±0.5 °C and are used to obtain relative humidity and when 'layered' sections of the atmosphere are used to compute equivalent weighted sound attenuations in each one-third octave band, sufficient sections being used to the satisfaction of the certificating authority; or

b) where the peak noy values at the time of PNLT, after adjustment to reference conditions, occur at requencies of less than or equal to 400 Hz.

2.1.7 Reference approach speed

The reference approach speed is currently contained in 3.6.3.1(b) of Chapter 3 of Annex 16, Volume 1 as $1.3V_S$ + 19 km/h ($1.3V_S$ + 10 kt). There is

a change being made to the definition of stall speed, for airworthiness reasons, to alter the current minimum speed VS definition to a stall speed during a 1-g manoeuvre (ie. a flight load factor of unity) V_{S1g}. In terms of the new definition the approach reference speed becomes $1.23V_{S1g}$ + 19 km/h, ($1.23V_{S1g}$ + 10 kt) which can be taken as equivalent to the reference speed contained in Chapter 3.

2.2 ANALYTICAL PROCEDURES

Analytical equivalent procedures rely upon available noise and performance data obtained from flight test for the aeroplane type. Generalised relationships between noise, power and distance (NPD plots see 2.1.2.1) and adjustment procedures for speed changes in accordance with the methods of Appendix 1 or 2 of Annex 16, Volume 1, are combined with certificated aeroplane aerodynamic performance data to determine noise level changes resulting from type design changes. These noise level increments are then applied to noise levels in accordance with paragraph 2.1.2.2 of this manual.

2.2.1 Flyover noise levels with power cut-back

Note: The “average engine” spool-down time should reflect a 1.0 second minimum altitude recognition lag time to account for pilot response.

2.2.1.1 Flyover noise levels with power cut-back may be established from the merging of PNLT versus time measurements obtained during constant power operations. As seen in Fig. 4(a) the 10 dB-down PNLT noise time history recorded at the flyover point may contain portions of both full power and cut-back power noise time histories. Provided these noise time histories, the average engine spool-down thrust characteristics and the aeroplane flight path during this period (See Fig. 4(b)), which includes the transition from full to cut-back power, are known, the flyover noise level may be computed.

2.2.1.2 Where the full power portion of the noise time history does not intrude upon the 10 dB-down time history of the cut-back power, the flyover noise levels may be computed from a knowledge of the NPD characteristics and the effect of the average spool-down thrust characteristicson the aeroplane flight path.

Note: To ensure that the full power portion of the noise time history does not intrude upon the 10 dB-down noise levels, PNLTM (after cutback) − PNLT (before cutback) ≥ 10.5 dB

2.2.2 Equivalent procedures based on analytical methods

Noise certification approval has been given for applications based on type design changes that result in predictable noise level differences including the following:

a) changes to the originally certificated take-off or landing mass which lead to changes in distance between the aeroplane and the microphone for the take-off case and changes to the approach power. In this case the NPD data may be used to determine the noise certification level of the derived version;

b) noise changes due to engine power changes. However, care should be taken to ensure that when NPD plots are extrapolated the relative contribution of the component noise sources to the Effective Perceived Noise Level remains essentially unchanged and a simple extrapolation of the noise/power and noise/distance curves can be made. Among the items which should be considered in extension of the NPD are:

− the 90% confidence interval at the extended power;

− aeroplane/engine source noise characteristics and behaviour;

− engine cycle changes; and

− quality of data to be extrapolated.

c) aeroplane engine and nacelle configuration and acoustical treatment changes, usually leading to changes in EPNL of less than one decibel. However, it should be ensured that new noise sources are not introduced by modifications made to the aeroplane, engine or nacelles. A validated analytical noise model approved by the certificating authority may be used to derive predictions of noise increments. The analysis may consist of modelling each aeroplane component noise source and projecting these to flight conditions in a manner similar to the static test procedure described in paragraph 2.3. A model of detailed spectral and directivity characteristics for each aeroplane noise component may be developed by theoretical and/or empirical analysis. Each component should be correlated to the parameter(s) which relates to the physical behaviour of source mechanisms. The source mechanisms, and subsequently the correlating parameters, should be identified through use of other supplemental tests such as engine or component tests. As described in paragraph 2.3 an EPNL representative of flight conditions should be computed by adjusting aeroplane component noise sources for forward speed effects, number of engines and shielding, reconstructing the total noise spectra and projecting the total noise spectra to flight conditions by accounting for propagation effects. The effect of

changes in acoustic treatment, such as nacelle lining, may be modelled and applied to the appropriate component noise sources. The computation of the total noise increments, the development of the changed version NPD, and the evaluation of the changed version certification levels should be made using the procedures in paragraphs 2.3.4.12 and 2.3.4.13. Guidance material on confidence interval computations is provided in Appendix 1.

d) airframe design changes such as changes in fuselage length, flap configuration and engine installation, that could indirectly affect noise levels because of an effect on aeroplane performance (increased drag for example). Changes in aeroplane performance characteristics derived from aerodynamic analysis or testing have been used to demonstrate how these changes affect the aeroplane flight path and hence the demonstrated noise levels of the aeroplane.

In these cases care should be exercised to ensure that the airframe changes do not introduce significant new noise sources nor modify existing source generation or radiation characteristics. In such instances the magnitude of such effects may need to be established by test.

2.3 STATIC TESTS AND PROJECTIONS TO FLIGHT NOISE LEVELS

2.3.1 General

2.3.1.1 Static test evidence provides valuable definitive information for deriving the noise levels resulting from changes to an aeroplane powerplant or the installation of a broadly similar powerplant into the airframe following initial noise certification of the flight datum aeroplane. This involves the testing of both the flight datum and derivative powerplants using an open-air test facility whereby the effect on the noise spectra of the engine modifications in the aeroplane may be assessed. It can also extend to the use of component test data to demonstrate that the noise levels remain unchanged where minor development changes have been made.

2.3.1.2 Approval of equivalent procedures for the use of static test information depends critically upon the availability of an adequate approved data base (NPD plot) acquired from the flight testing of the flight datum aeroplane.

2.3.1.3 Static tests can provide sufficient additional data or noise source characteristics to allow a prediction to be made of the effect of changes on the noise levels from the aeroplane in flight.

2.3.1.4 Types of static test accepted for the purposes of certification compliance demonstration in aeroplane development include engine and component noise tests and performance testing. Such tests are useful for assessing the effects of mechanical and thermodynamic cycle changes to the engine on the individual noise sources.

2.3.1.5 Static engine testing is dealt with in detail in subsequent sections. The criteria for acceptance of component tests are less definable. There are many instances, particularly when only small EPNL changes are expected, that component testing provides an adequate demonstration of noise impact. These include, for example:

a) changes in the specification of sound absorbing linings within an engine nacelle;

b) changes in the mechanical or aerodynamic design of the fan, compressor or turbine;

c) changes to combustor designs; and

d) minor exhaust system changes.

2.3.1.6 Each proposal by the applicant to use component test data should be considered by the certificating authority with respect to the significance of the relevant affected source on the EPNL of the aeroplane.

2.3.2 Limitation on the projection of static to flight data

Details of the acceptability, use and applicability of static test data are contained in subsequent sections.

2.3.2.1 The amount by which the measured noise levels of a derivative engine will differ from the reference engine is a function of several factors, including:

a) thermodynamic changes to the engine cycle, including increases in thrust;

b) design changes to major components, e.g. the fan, compressor, turbine, exhaust system, etc.; and

c) changes to the nacelle.

2.3.2.2 Additionally, day-to-day and test site-to-site variables can influence measured noise levels and therefore the test, measurement and analysis procedures described in this manual are designed to account for these effects. In

order that the degree of change resulting from aspects such as (a), (b) and (c) above, when extrapolated to flight conditions, are constrained to acceptable amounts before a new flight test is required, a limit is needed that can be used uniformly by certificating authorities.

2.3.2.3 The recommended guideline for this limit is that the summation of the magnitudes, neglecting signs, of the noise changes, for the three reference certification conditions, between the flight datum aeroplane and the derived version, at the same thrust and distance (for the derived version), is no greater than 5 EPNdB with a maximum of 3 EPNdB at any one of the reference conditions (see figure 5).

2.3.2.4 For differences greater than this additional flight testing at conditions where noise levels are expected to change is recommended to establish a new flight NPD data base.

2.3.2.5 Provided the detailed prediction procedures used are verified by flight test for all the types of noise sources, ie. tones, non-jet broadband and jet noise relevant to the aeroplane under consideration and there are no significant changes in installation effects between the aeroplane used for the verification of the prediction procedures and the aeroplane under consideration, the procedure may be employed without the limitations described above.

2.3.2.6 In addition to the limitations described above a measure of acceptability regarding methodologies for static to flight projection is also needed that can be used uniformly by certificating authorities. This measure can be derived as residual NPD differences between the flight test data and the projected static to flight data for the original aeroplane version. The guideline for a measure of acceptability is to limit these residuals to 3 EPNdB at any one of the reference conditions.

2.3.2.7 In the determination of the noise levels of the modified or derived version the same analytical procedures as used in the first static to flight calculations for the noise certification of the aeroplane type shall be used.

2.3.3 Static engine tests

2.3.3.1 General

2.3.3.1.1 Data acquired from static tests of engines of similar designs to those that were flight tested may be projected, when appropriate, to flight conditions and, after approval, used to supplement an approved NPD plot for the purpose of demonstrating compliance with the Annex 16, Volume 1, provisions

in support of a change in type design. This section provides guidelines on static engine test data acquisition, analysis and normalisation techniques. The information provided is used in conjunction with technical considerations and the general guidelines for test site, measurement and analysis instrumentation, and test procedures provided in the latest version of the Society of Automotive Engineers (SAE) ARP 1846, "Measurement of Noise from Gas Turbine Engines During Static Operation". The engine designs and the test and analysis techniques to be used should be presented in the test plan and submitted, for approval, to the certificating authority for concurrence prior to testing. Note that test restrictions defined for flight testing in conformity with Annex 16, Volume 1, are not necessarily appropriate for static testing. (SAE ARP 1846 provides guidance on this subject).

2.3.3.1.2 For example, the measurement distances associated with static tests are substantially less than those encountered in flight testing and may permit testing in atmospheric conditions not permitted for flight testing by Annex 16, Volume 1. Moreover, since static engine noise is a steady sound pressure level rather than the transient noise level of a flyover, the measurement and analysis techniques may be somewhat different for static noise testing.

2.3.3.2 Test site requirements

The test site should meet at least the criteria specified in SAE ARP 1846. Different test sites may be selected for testing differing engine configurations provided the acoustic measurements from the different sites can be adjusted to a common reference condition.

2.3.3.3 Engine inlet bell mouth

The installation of a bell mouth forward of the engine inlet may be used with turbofan or turbojet engines during static noise tests. Such an installation is used to provide a simulated flight condition of inlet flow during static testing. Production inlet acoustic lining and spinners are also to be installed during noise testing.

2.3.3.4 Inflow control devices

2.3.3.4.1 The use of static engine test noise data for the noise certification of an aeroplane with a change of engine to one of a similar design requires the use of an approved Inflow Control Device (ICD) for high bypass engines (BPR > 2.0). The ICD should meet the following requirements:

a) The specific ICD hardware must be inspected by the certificating

authority to ensure that the ICD is free from damage and contaminants that may affect its acoustic performance;

b) The ICD must be acoustically calibrated by an approved method (such as that provided in paragraph 2.3.3.4.3) to determine its effect on sound transmission in each one-third octave band;

c) Data obtained during static testing must be corrected to account for sound transmission effects that are caused by the ICD. The corrections shall be applied to each one-third octave band of data measured;

d) The ICD position relative to the engine inlet lip must be determined and the calibration must be applicable to that position; and

e) No more than one calibration is required for an ICD hardware design, provided that there is no deviation from the design for any one ICD serial number hardware set.

2.3.3.4.2 It is not necessary to apply the ICD calibration corrections if the same ICD hardware (identical serial number) is used as was previously used in the static noise test of the flight engine configuration, and the fan tones for both engines remain in the same one-third octave bands.

2.3.3.4.3 ICD calibration

An acceptable ICD calibration method is as follows:

a) Place an acoustic driver(s) on a simulated engine centreline in the plane of the engine inlet lip. Locate the calibration microphones on the forward quadrant azimuth at a radius between 50 ft and 150 ft that provides a good signal-to-ambient noise ratio and at each microphone angle to be used to analyse static engine noise data. Locate a reference near-field microphone on the centreline of and within 2 ft of the acoustic centre of the acoustic driver(s);

b) Energise the acoustic driver with pink noise without the ICD in place. Record the noise for a minimum of 60 s duration following system stabilisation. The procedure must be conducted at a constant input voltage to the acoustic driver(s);

c) Repeat item (b), alternately with and without the ICD in place. A minimum of three tests of each configuration (with and without ICD in place) is required. To be acceptable, the total variation of the 55° microphone online OASPL signal (averaged for a 1 minute duration) for all three test conditions of each configuration shall not exceed 0.5 dB;

Note: Physically moving the ICD alternately in and out of place for this calibration may be eliminated if it is demonstrated that the ICD positioning does not affect the calibration results.

d) All measured data are to be corrected for sound pressure level variations as measured with the near-field microphone and for atmospheric absorption to 77 °F and 70 per cent RH conditions using the slant distance between the outer microphones and the acoustic driver(s);

e) The calibration for each onethird octave band at each microphone is the difference between the average of the corrected SPL's without the ICD in place and the average of the corrected SPL's with the ICD in place; and

f) The tests must be conducted under wind and thermal conditions that preclude acoustic shadowing at the outer microphones and weather induced variations in the measured SPL data. Refer to Figure 6, Section 2.3.3.7.

In some cases large fluctuations in the value of the calibrations across adjacent 1/3 octave bands and between closely spaced angular positions of microphones can occur. These fluctuations can be related to reflection effects caused by the calibration procedure and care must be taken to ensure that they do not introduce or suppress engine tones. This may be done by comparing effective perceived noise levels computed with:

a) the ICD calibrations as measured;

b) a mean value of the calibration curves; and

c) the calibration values set to zero.

2.3.3.5 Measurement and analysis

Measurement and analysis systems used for static test, and the modus operandi of the test programme, may well vary according to the specific test objectives, but in general they should conform with those outlined in SAE ARP 1846. Some important factors to be taken into account are highlighted in subsequent sections.

2.3.3.6 Microphone locations

2.3.3.6.1 Microphones should be located over an angular range sufficient to include the 10 dB-down times after projection of the static noise data to flight conditions. General guidance in SAE ARP 1846, describing microphone locations is sufficient to ensure adequate definition of the engine noise source characteristics.

2.3.3.6.2 The choice of microphone location with respect to the test surface depends on the specific test objectives and the methods to be used for data normalisation. Certification experience with static engine testing has been primarily limited to microphone installations near the ground or at engine centreline height. In general, because of the difficulties associated with obtaining free-field sound pressure levels that are often desirable for extrapolating to flight conditions, near-ground-plane microphone installations or a combination of ground-plane and elevated microphones have been used. Consistent microphone locations, heights, etc. are recommended for noise measurements of both the prior approved and changed version of an engine or nacelle.

2.3.3.7 Acoustic shadowing

2.3.3.7.1 Where ground plane microphones are used, special precautions are necessary to ensure that consistent measurements, e.g. free from "acoustic shadowing" (refraction) effects, will be obtained. When there is a wind in the opposite direction to the sound wave propagating from the engine, or when there is a substantial thermal gradient in the test arena, refraction can influence near ground plane microphone measurements to a larger degree than measurements at greater heights.

2.3.3.7.2 Previous evidence, or data from a supplemental test, may be used to demonstrate that testing at a particular test site results in consistent measurements, including the absence of shadowing. In lieu of this evidence, a supplemental noise demonstration test should include an approved method to indicate the absence of shadowing effects on the ground plane measurements.

2.3.3.7.3 The following criteria are suggested for certain test geometries, based on measurements of three weather parameters as follows:

− average wind speeds at engine centreline height (WCL);

− air temperature at engine centreline height (TCL); and

− air temperature near ground plane microphone height (TMIC).

a) The instruments for these measurements should be collocated and placed close to the 90° noise measurement position without impeding the acoustic measurement;

b) The suggested limits are additional to the wind and temperature limits established by other criteria (such as the maximum wind speed at the

microphone if wind screens are not used); and

c) Wind and temperature criteria that have been observed to provide consistent measurements that preclude any influence of acoustic shadowing effects on ground plane measurements are defined in Figure 6.

The line defines a boundary between the absence of shadowing and the possible onset of spectral deficiencies in the very high frequencies. Testing is permitted provided that the test day conditions are such that the average (typically 30 s) wind speed at engine centreline height falls below the line shown, and that wind gusting does not exceed the value of the line shown by more than 5.5 km/h (3 kt). Wind speeds in excess of the linear relationship shown, between 7 and 22 km/h (4 and 12 kt), may indicate the need to demonstrate the absence of spectral abnormalities, either prior to or at the time of test when the wind direction opposes the direction of sound propagation.

When the temperature at the ground microphone height is not greater than the temperature at the engine centreline height plus 4° K, shadowing effects due to temperature gradients can be expected to be negligible.

Note: Theoretical analyses and the expression of wind criteria in terms of absolute speed rather than the vector reduction suggest that the noted limits may be unduly stringent in some directions.

2.3.3.8 Engine power test conditions

A range of static engine operating conditions should be selected to correspond to the expected maximum range of in-flight engine operating conditions for the appropriate engine power setting parameter. A sufficient number of stabilised engine power settings over the desired range should be included in the test to ensure that the 90 per cent confidence intervals in flight projected EPNL can be established (see paragraph 3 of Appendix 1 to this manual).

2.3.3.9 Data system compatibility

2.3.3.9.1 If more than one data acquisition system and/or data analysis system is used for the acquisition or analysis of static data, compatibility of the airframe and engine manufacturers' systems is necessary. Compatibility of the data acquisition systems can be accomplished through appropriate calibration. Compatibility of the data analysis systems can be verified by analysing the same data samples on both systems. The systems are compatible if the resulting differences are no greater than 0.5 EPNdB. Evaluation should be conducted at

flight conditions representative of those for certification.

2.3.3.9.2 The use of pseudo random noise signals with spectral shape and tonal content representative of turbo-fan engines is an acceptable alternative to using actual engine noise measurements for analysis system compatibility determination. The systems are compatible if the resulting differences are no greater than 0.5 PNdB for an integration time of 32 seconds.

2.3.3.10 Data acquisition, analysis and normalisation

For each engine power setting designated in the test plan, the engine performance, meteorological and sound pressure level data should be acquired and analysed using instrumentation and test procedures described in SAE ARP 1846. Sound measurements should be normalised to consistent conditions and include 24 1/3-octave band sound pressure levels between band centre frequencies of 50 Hz to 10 kHz for each measurement (microphone) station. Before projecting the static engine data to flight conditions, the sound pressure level data should be corrected for:

a) the frequency response characteristics of the data acquisition and analysis system; and

b) contamination by background ambient or electrical system noise. (See Appendix 3).

2.3.4 Projection of static engine data to aeroplane flight conditions

2.3.4.1 General

2.3.4.1.1 The static engine sound pressure level data acquired at each angular location should be analysed and normalised to account for the effects identified in 2.3.3.8. They should then be projected to the same aeroplane flight conditions used in the development of the approved NPD plot.

2.3.4.1.2 As appropriate, the projection procedure includes:

a) effects of source motion including Doppler effects;

b) number of engines and shielding effects;

c) installation effects;

d) flight geometry;

e) atmospheric propagation, including spherical wave divergence and atmospheric attenuation; and

f) flight propagation effects including ground reflection and lateral attenuation. (See paragraph 2.3.4.11).

2.3.4.1.3 To account for these effects, the measured total static noise data should be analysed to determine contributions from individual noise sources. After projecting the 1/3 octave-band spectral data to flight conditions, Effective Perceived Noise Levels should be calculated for the revised NPD plot. Guidelines on the elements of an acceptable projection procedure are provided in this section. The process is also illustrated in Figs 7 and 8.

2.3.4.1.4 It is not intended that the procedure illustrated in Figs 7 and 8 should be exclusive. There are several options, depending upon the nature of the powerplant noise sources and the relevance of individual noise sources to the Effective Perceived Noise Level of the aeroplane. The method presented does, however, specify the main features that should be considered in the computational procedure.

2.3.4.1.5 It is also not necessary that the computations should always be carried out in the order specified. There are interrelations between the various steps in the procedure which depend on the particular form of the computation being followed. Hence the most efficient manner of structuring the computation cannot always be pre-determined.

2.3.4.1.6 There are several engine installation effects which can modify the generated noise levels but which cannot be derived from static tests. Additional noise sources such as jet/flap or jet/wind interaction effects may be introduced on a derived version of the aeroplane which are not present on the flight datum aeroplane. Far-field noise directivity patterns (field shapes) may be modified by wing/nacelle or jet-byjet shielding, tailplane and fuselage scattering or airframe reflection effects. However, general methods to adjust for these effects are not yet available. It is therefore important that, before the following procedures are approved for the derived version of the aeroplane, the geometry of the airframe and engines in the vicinity of the engines be shown to be essentially identical to that of the flight datum aeroplanes so that the radiated noise is essentially unaffected.

2.3.4.2 Normalisation to reference conditions

2.3.4.2.1 The analysed static test data should be normalised to freefield conditions in the Annex 16, Volume 1 reference atmosphere. This adjustment can only be applied with a knowledge of the total spectra being the summation of all the noise source spectra computed as described in paragraphs 2.3.4.3 to

2.3.4.5.

2.3.4.2.2 The required adjustments include:

a) Atmospheric absorption: adjustments to account for the acoustical reference day atmospheric absorption are defined in SAE ARP 866A (revised 15th March 1975). In the event that minor differences in absorption values are found in SAE ARP 866A between equations, tables or graphs, the equations should be used.

The atmospheric absorption should be computed over the actual distance from the effective centre of each noise source to each microphone, as determined in 2.3.4.5; and

b) Ground reflection: examples of methods for obtaining freefield sound pressure levels are described in SAE AIR 1672B-1983 or Engineering Sciences Data Unit, ESDU Item 80038 Amendment A.

Spatial distribution of noise sources does not have a first order influence on ground reflection effects and hence may be disregarded. It is also noted that measurements of far-field sound pressure levels with ground-plane microphones may be used to avoid the large spectral irregularities caused by interference effects at frequencies less than 1 kHz.

2.3.4.3 Separation into broadband and tone noise

2.3.4.3.1 The purpose of procedures described in this section is to identify all significant tones in the spectra, firstly to ensure that tones are not included in the subsequent estimation of broadband noise, and secondly to enable the Dopplershifted tones (in-flight) to be allocated to the correct 1/3 octave band at appropriate times during a simulated aeroplane flyover.

2.3.4.3.2 Broadband noise should be derived by extracting all significant tones from the measured spectra. One concept for the identification of discrete tones is that used in Annex 16, Volume 1, Chapter 3 (Appendix 2) for tone correction purposes (that is, considering the slopes between adjacent 1/3 octave band levels). Care must be taken to avoid regarding tones as "non protrusive" when the surrounding broad band sound pressure level is likely to be lower when adjusted from static to flight conditions, or classifying a closely grouped pair, or series, of tones as broadband noise. One technique for resolving such problems is the use of narrow band analysis with a bandwidth of less than 50 Hz.

2.3.4.3.3 Narrow band analysis can also be used to check the validity of other tone identification procedures in establishing the spectral character at critical locations in the sound field, e.g. around the position of peak PNLT, or where predominant turbomachinery tones exist.

2.3.4.4 Separation into contributing noise sources

2.3.4.4.1 The number of noise sources which require identification will to some extent depend on the engine being tested and the nature of the change to the engine or nacelle. Separation of broadband noise into the combination of noise generated by external jet mixing and by internal noise sources is the minimum and sometimes adequate requirement. A more sophisticated analysis may be necessary depending upon the significance of the contribution from other individual sources, which could involve identifying broadband noise from fan, compressor, combustor and turbine. Furthermore, for fan and compressor noise, the split of both the broadband and the tone noise between that radiating from the engine intake and that from the engine exhaust nozzle(s) could be a further refinement.

2.3.4.4.2 To meet the minimum requirement, separation of sources of broadband noise into those due to external jet mixing and those generated internally can be carried out by estimating the jet noise by one or more of the methods identified below, and adjusting the level of the predicted spectrum at each angle to fit the measured low frequency part of the broadband spectrum at which jet noise can be expected to be dominant.

2.3.4.4.3 There are three means which have been used to obtain predicted jet noise spectra shapes:

a) For single-stream engines with circular nozzles the procedure detailed in SAE ARP 876C-1985 may be used. However, the engine geometry may possess features which can render this method inapplicable. Example procedures for coaxial flow engines are provided in SAE AIR 1905-1985;

b) Analytical procedures based on correlating full scale engine data with model nozzle characteristics may be used. Model data have been used to supplement full scale engine data, particularly at low power settings, because of the uncertainty in defining the level of jet noise at the higher frequencies where noise from other engine sources may make a significant contribution to the broadband noise; and

c) Special noise source location techniques are available which, when used

during full-scale engine tests, can identify the positions and levels of separate engine noise sources.

2.3.4.5 Noise source position effects

2.3.4.5.1 Static engine noise measurements are often made at distances at which engine noise sources cannot be truly treated as radiating from a single acoustic centre. This may not give rise to difficulties in the extrapolation to determine the noise increments from static data to flight conditions because noise increments in EPNL are not particularly sensitive to the assumption made regarding the spatial distribution of noise sources.

2.3.4.5.2 However, in some circumstances (for example, where changes are made to exhaust structures, and the sources of external jet-mixing noise are of overriding significance) it may be appropriate to identify noise source positions more accurately. The jet noise can be considered as a noise source distributed downstream of the engine exhaust plane. Internal sources of broadband engine noise may be considered as radiating from the intake and the exhaust.

2.3.4.5.3 There are three principal effects to be accounted for as a consequence of the position of the noise source differing from the "nominal" position assumed for the "source" of engine noise:

a) Spherical divergence: the distance of the source from the microphone differs from the nominal distance; an inverse square law adjustment needs to be applied.

b) Directivity: the angle subtended by the line from the source to the microphone and the source to the engine centreline differs from the nominal angle; a linear interpolation should be made to obtain data for the proper angle.

c) Atmospheric attenuation: the difference between the true and the nominal distance between the source and the microphone alters the allowance made for atmospheric attenuation in paragraph 2.3.4.2 above.

2.3.4.5.4 Source position can be identified either from noise source location measurements (made either at full or model scale), or from a generalised data base.

Note: No published standard on coaxial jet noise source distribution is currently available. An approximate distribution for a single jet is given by the following equation (see References 1 and 2):

$$x/D = \left(0.057S + 0.021S^2\right)^{-1/2}$$

where:

S is the Strouhal number fD/V_j;

x is the distance downstream from the nozzle exit;

D is the nozzle diameter based on total nozzle exit area;

V_j is the average jet velocity for complete isentropic expansion to ambient pressure from average nozzle-exit pressure and temperature; and

f is the 1/3 octave band centre frequency.

2.3.4.6 Engine flight conditions

2.3.4.6.1 Some thermodynamic conditions within an engine tested statically differ from those that exist in flight and account should be taken of this. Noise source strengths may be changed accordingly. Therefore, values for key correlating parameters for component noise source generation should be based on the flight condition and the static data base should be entered at the appropriate correlating parameter value. Turbomachinery noise levels should be based on the inflight corrected rotor speeds $\frac{N_1}{\sqrt{\theta_{t_2}}}$ and jet noise levels should be based on the relative jet velocities that exist at the flight condition.

2.3.4.6.2 The variation of source noise levels with key correlating parameters can be determined from the static data base which includes a number of different thermodynamic operating conditions.

2.3.4.7 Noise source motion effects

The effects of motion on jet noise differ from speed effects on other noise sources, and hence are considered separately during static-to-flight projection.

2.3.4.7.1 External jet noise

Account should be taken of the frequency-dependent jet relative velocity effects and convective amplification effects. Broadly, two sources of information may be used to develop an approved method for defining the effect of flight on external jet noise:

a) For single-stream engines having circular exhaust geometries, SAE ARP 876C-1985 provides guidance. However, additional supporting evidence may be needed to show when jet noise is the major contributor to the noise from an engine with a more complex nozzle assembly; and

b) Full scale flight data on a similar exhaust geometry can provide

additional evidence. In general, however, because of the difficulty of defining high frequency effects in the presence of internallygenerated engine noise, it may be necessary to provide additional supporting information to determine the variation of EPNL, with changes of jet noise spectra at high frequencies.

2.3.4.7.2 Noise sources other than jet noise

In addition to the Doppler frequency effect on the non-jet noise observed on the ground from an aeroplane flyover, the noise generated by the engine's internal components and the airframe can be influenced by source amplitude modification, and directivity changes:

a) Doppler Effect: frequency shifting that results from motion of the source (aeroplane) relative to a microphone is accounted for by the following equation:

$$f_{flight} = \frac{f_{static}}{1 - M \cos \lambda}$$

where:

fflight = flight frequency;

fstatic = static frequency;

M = Mach number of aeroplane; and

λ = angle between the flight path in the direction of flight and a straight line connecting the aeroplane and the microphone at the time of sound emission.

It should be noted for those 1/3 octave band sound pressure levels dominated by a turbo-machinery tone, the Doppler shift may move the tone (and its harmonics) into an adjacent band.

b) Source amplitude modification and directivity changes: sound pressure level adjustments to airframe generated noise that result from speed changes between the datum and derivative version is provided for in paragraph 2.3.4.9, Airframe noise.

For noise generated internally within the engine, e.g. fan noise, there is no consensus of opinion on the mechanisms involved or a unique adjustment method that accounts for the detailed source modification and sound propagation effects.

If an adjustment is used, the same technique must be applied to both the flight datum and derivative configuration when establishing noise changes. In such instances the adjustment for sound pressure level changes that result form the motion of the source (aeroplane) relative to the microphone may be

accounted for using the equation:

$$SPL_{flight} = SPL_{static} - K\log(1 - M\cos\lambda)$$

where:

SPL_{flight} = flight sound pressure level;

SPL_{static} = static sound pressure level; and

M and λ are defined above and K is a constant.

Theoretically K has a value of 40 for a point noise source but a more appropriate value may be obtained by comparing static and flight data for the flight datum aeroplane.

2.3.4.8 Aeroplane configuration effects

2.3.4.8.1 The contribution from more than one engine on an aeroplane is normally taken into account by adding 10log N, where N is the number of engines, to each component noise source. However, it might be necessary to compute the noise from engines widely spaced on large aeroplanes particularly in the approach case if they include both underwing and fuselage mountings. The noise from the intakes of engines mounted above the fuselage is known to be shielded.

2.3.4.8.2 If engine installation effects change between the flight datum aeroplane and a derived version, account should be taken of the change on sound pressure levels which should be estimated according to the best available evidence.

2.3.4.9 Airframe noise

2.3.4.9.1 To account for the contribution of airframe noise, measured flight datum airframe noise on its own or combined with an approved airframe noise analytical model may be used to develop an airframe noise data base. The airframe-generated noise, which can be treated as a point source for adjustment purposes, is normalised to the same conditions as those of the other (engine) sources, with due account for the effects of spherical divergence, atmospheric absorption and airspeed as described in section 8 and 9 of Appendix 2 of Annex 16, Volume 1.

2.3.4.9.2 Airframe noise for a specific configuration varies with airspeed (see Reference 3) as follows:

$$\Delta SPL_{airframe} = 50\log(V_{REF}/V_{TEST})$$

where:

V_{REF} is approved reference airspeed for the flight datum aeroplane; and

V_{TEST} is model or measured airspeed.

2.3.4.9.3 The above equation is also valid for adjustments to EPNL where an empirically derived coefficient replaces the coefficient 50 since that number may be somewhat configuration dependent. However, approval of the certification authority is required for values other than 50.

2.3.4.10 Aeroplane flight path considerations

When computing noise levels corresponding to the slant distance of the aeroplane in flight from the noise measuring point, the principal effects are spherical divergence (inverse square law adjustments from the nominal static distance) and atmospheric attenuation, as described in sections 8 and 9 of Appendix 2 of Annex 16, Volume 1. Further, account should be taken of the difference between the static engine axis and that axis in flight relative to the reference noise measuring points. The adjustments should be applied to the component noise source levels that have been separately identified.

2.3.4.11 Total noise spectra

2.3.4.11.1 Both the engine tonal and broadband noise source components in flight, as discussed earlier, together with the airframe noise and any installation effects, are summed on a mean-square pressure basis to construct the spectra of total aeroplane noise levels.

2.3.4.11.2 During the merging of broadband and tonal components consideration should be given to appropriate band-sharing of discrete frequency tones.

2.3.4.11.3 The effects of ground reflections must be included in the estimate of freefield sound pressure levels to simulate the sound pressure levels that would be measured by a microphone at a height of 1.2 m above a natural terrain. Information in SAE AIR 1672B-1983 or Engineering Science Data Unit, ESDU data item 80038 Amendment A may be used to apply adjustments to the freefield spectra to allow for flight measurements being made at 1.2 m (4 ft). Alternatively, the ground reflection correction can be derived from other approved analytical or empirically derived models. Note that the Doppler

correction for a static source at frequency f_{static} applies to a moving (aeroplane) source at a frequency f_{flight} where $f_{flight} = f_{static}/(1 - M\cos\lambda)$ the terminology of 2.3.4.7.2(a).

2.3.4.11.4 This process is repeated for each measurement angle and for each engine power setting.

2.3.4.11.5 With regard to lateral attenuation, information in SAE AIR 1751-1981 applicable to the computation of lateral noise may be applied.

2.3.4.12 EPNL computations

For EPNL calculations, a time is associated with each extrapolated spectrum along the flightpath. (Note: Time is associated with each measurement location with respect to the engine/aeroplane reference point and the aeroplane's true airspeed along the reference flight path assuming zero wind). For each engine power setting and minimum distance, an EPNL is computed from the projected time history using the methods described in Annex 16, Volume 1, Appendices 1 and 2.

2.3.4.13 Changes to noise levels

2.3.4.13.1 An NPD plot can be constructed from the projected static data for both the original (flight datum) and the changed versions of the engine or nacelle tested. Comparisons of the noise vs engine power relationships for the two configurations at the same appropriate minimum distance, will determine whether or not the changed configuration resulted in a change to the noise level from an engine noise source. If there is a change in the level of source noise, a new in-flight aeroplane NPD plot can be developed by adjusting the measured original NPD plot by the amount of change indicated by the comparison of the static-projected NPD plots for the original and changed versions within the limitations specified in 2.3.2 for Effective Perceived Noise Level.

2.3.4.13.2 The noise certification levels for the derived version may be obtained by entering the NPD plots at the relevant reference engine power and distance.

SECTION 3 - EQUIVALENT PROCEDURES FOR PROPELLER DRIVEN AEROPLANES OVER 9000 kg

The following procedures have been used as equivalent in stringency to Chapter 3 and Chapter 5, Annex 16, Volume 1 for propeller driven aeroplanes with maximum certificated take-off mass exceeding 9000 kg.

3.1 FLIGHT TEST PROCEDURES

3.1.1 Flight path intercept procedures

Flight path intercept procedures, as described in 2.1.1 of this manual, have been used to meet the demonstration requirements of noise certification in lieu of full take-offs and/or landings.

3.1.2 Generalised flight test procedures

Generalised flight test procedures (other than normal noise demonstration take-offs and approaches) have been used to meet two equivalency objectives:

a) to acquire noise data over a range of engine power settings at one or more heights: this information permits the development of generalised noise characteristics necessary for certification of a "family" of similar aeroplanes. The procedures used are similar to those described in 2.1.2.1 with the exception that the NPD plots employ engine noise performance parameters (μ) of M_H (propeller helical tip Mach number) and SHP/δ_{amb} (shaft horse power) (see Fig 3), where δ_{amb} is defined in 2.1.2.1.3.

In order to ensure that propeller inflow angles are similar throughout the development of the noisesensitivity data as the aeroplane mass changes, the airspeed of the aeroplane used in the flight tests for developing the lateral and flyover data shall be V_2 + 19 km/h (V_2 + 10 kt) to within ± 6km/h or ±3 kt appropriate for the mass of the aeroplane during the test.

For the development of the NPD data for the approach case the speed and approach angle constraints imposed by 5.6.3(b), 5.7.5, 3.6.3 and 3.7.5 of Chapters 5 and 3 of Annex 16, Volume 1, cannot be satisfied over the typical range of power needed. For the approach case the speed shall be maintained at 1.3 V_S + 19 km/h (1.3 V_S + 10 kt) to within ±6 km/h or ±3 kt and flyover height over the microphone maintained at 400 ft ±100 ft. However, the approach angle

at the test power shall be that which results from the aeroplane conditions, ie. mass, configuration, speed and power; and

b) Noise level changes determined by comparisons of fly-over noise test data for different developments of an aeroplane type, for example, a change in propeller type, have been used to establish certification noise levels of a newly derived version as described in 2.1.2.2.

3.1.3 Determination of the lateral noise certification level

Determination of the lateral noise certification level employing an alternative procedure using two microphone stations located symmetrically on either side of the take-off flight path similar to that as described in 2.1.3 has been approved. However, when this procedure is used, matching data from both lateral microphones for each fly-by must be used for the lateral noise determination; cases where data from only one microphone is available for a given fly-by must be omitted from the determination. The following paragraphs describe the procedures for propeller-driven heavy aeroplanes.

3.1.3.1 The lateral Effective Perceived Noise Level from propeller driven aeroplanes when plotted against height opposite the measuring sites can exhibit distinct asymmetry. The maximum EPNL on one side of the aeroplane is often at a different height and noise level from that measured on the other side.

3.1.3.2 In order to determine the average maximum lateral EPNL, i.e. the certification sideline noise level, it is therefore necessary to undertake a number of flights over a range of heights to define the noise versus height characteristics for each side of the aeroplane. A typical height range would cover between 30 m (100 ft) and 550 m (1,800 ft) above a track at right angles to and midway along the line joining the two microphone stations. The inter-section of the track with this line is defined as the reference point.

3.1.3.3 Since experience has shown the maximum lateral noise level may often be near the lower end of this range a minimum of six good sets of data, measured simultaneously from both sides of the flight track, should be obtained for a range of aeroplane heights as low as possible. In this case take-offs may be necessary, however care should be taken to ensure that the airspeed is stabilised to at least V_2 + 19 km/h (V_2 + 10 kt) over the 10 dB-down time period.

3.1.3.4 The aeroplane climbs over the reference point using take-off power, speeds and configuration as described in 3.6.2.1 c) and d) of Chapter 3 or 5.6.2.1 c) and d) of Chapter 5 of Annex 16, Volume 1.

3.1.3.5 The lateral certification noise level is obtained by finding the peak of the curve of noise level (EPNL) corrected to reference day atmospheric absorption values, plotted against aeroplane height above the reference point (see Fig. 9). This curve is described as a least squares curve fit through the data points defined by the median values of each pair of matched data measured on each side of the track (i.e. the average of the two microphone measurements for a given aeroplane height).

3.1.3.6 To ensure that the requirements of 5.4.2 of Appendix 2 or 5.5.2 of Appendix 1 of Annex 16, Volume 1, are met the 90 per cent confidence limits should be determined in accordance with paragraph 2.2 of Appendix 1 of this manual.

3.1.4 Measurements at non-reference points

3.1.4.1 In some instances test measurement points may differ from the reference measurement points specified in Chapters 3 and 5 of Annex 16, Volume 1. Under these circumstances an applicant may request approval of data that have been adjusted from actual measurements to the reference conditions for reasons described in 2.1.5.2 a), b) and c).

3.1.4.2 Noise measurements collected closer to the test aeroplane than at the certification reference points are particularly useful for correcting propeller noise data as they are dominated by low frequency noise. The spectra rolls off rapidly at higher frequencies and is often lost in the background noise at frequencies above 5000 Hz. Appendix 3 describes an alternative procedure.

3.1.4.3 Non-reference measurement points may be used provided that measured data are adjusted to reference conditions in accordance with the requirements of section 9 of Appendix 1 or 2 of Annex 16, Volume 1 and the magnitude of the adjustments does not exceed the limits in paragraphs 3.7.6 of Chapter 3 and 5.7.6 of Chapter 5 of the Annex.

3.1.5 Reference approach speed

The reference approach speed is currently contained in 3.6.3.1(b) of Chapter 3 of Annex 16, Volume 1 as 1.3 V_S + 19 km/h (1.3 V_S + 10 kt). There is a change being made to the definition of stall speed, for airworthiness reasons, to alter the current minimum speed V_S definition to a stall speed during a 1-g manoeuvre (i.e. a flight load factor of unity) V_{S1g}. In terms of the new definition the approach reference speed becomes 1.23 V_{S1g} + 19 km/h, (1.23 V_{S1g} + 10 kt) which can be taken as equivalent to the reference speed contained in Chapter 3.

3.2 ANALYTICAL PROCEDURES

3.2.1 Analytical equivalent procedures rely upon available noise and performance data for the aeroplane type. Generalised relationships between noise levels, propeller helical tip Mach number, and shaft horsepower and correction procedures for speed and height changes in accordance with the methods of Appendix 2 of Annex 16, Volume 1, are combined with certificated aeroplane performance data to determine noise level changes resulting from type design changes. The noise level changes are then added to or subtracted from the noise certification levels demonstrated by flight test measurements for the flight datum aeroplane.

3.2.2 Certifications using analytical procedures have been approved for type design changes that result in predictable noise level differences including the following:

a) an increase or decrease in maximum take-off and/or landing mass of the aeroplane from the originally certificated mass;

b) power increase or decrease for engines that are acoustically similar and fitted with propellers of the same type;

c) aeroplane, engine and nacelle configuration changes, usually minor in nature, including derivative aeroplane models with changes in fuselage length and flap configuration. However, care is needed to ensure that existing noise sources are not modified by these changes, e.g. by changing the flow field into the propellers; and

d) minor airframe design changes that could indirectly affect noise levels because of an impact on aeroplane performance (increased drag for example). Changes in aeroplane performance characteristics derived from aerodynamic analysis or testing have been used to demonstrate how these changes affect the aeroplane flight path and hence the demonstrated noise levels of the aeroplane.

3.3 GROUND STATIC TESTING PROCEDURES

3.3.1 General

Unlike the case of a turbojet or turbo fan powerplant, static tests involving changes to the propeller are not applicable to determining noise level changes in the development of a propeller driven aeroplane/powerplant family. This is caused by changes in the aero-acoustic operating conditions of the propeller

when run statically compared with conditions existing during flight. The propeller noise levels measured during a static test can include significant contributions from noise source components not normally important in flight. However, limited static tests on engines with propellers, which are used as engine loading devices can be utilised to determine small noise changes, as described below.

3.3.2 Guidance on the test site characteristics

Guidance on the test site characteristics data acquisition and analysis systems, microphone locations, acoustical calibration and measurement procedures for static testing is provided in SAE ARP 1846 and is equally valid in these respects for propeller power plants.

3.3.3 Static tests of the gas generator

3.3.3.1 Static tests of the gas generator can be used to identify noise changes resulting from changes to the design of the gas generators or the internal structure of the engine in the frequency ranges where there is a contribution to the aeroplane EPNL, or where that part of the spectrum is clearly dominated by the gas generator or ancillary equipment under circumstances where the propeller and its aerodynamic performance remains unchanged.

3.3.3.2 Such circumstances include, for example, changes to the compressor, turbine or combustor of the powerplant. The effect of such changes should be conducted under the same test, measurement, data reduction and extrapolation procedures as described in paragraph 2.3 for turbojet and turbofan engines. The noise from any propeller or other power extraction device used in static tests should be eliminated or removed analytically. For the purposes of aeroplane EPNL calculation, the measured flight datum aeroplane propeller contributions should be included in the computation process.

SECTION 4 - EQUIVALENT PROCEDURES FOR PROPELLER DRIVEN AEROPLANES NOT EXCEEDING 9000 kg

The following procedures have been used as equivalent in stringency to Chapter 6 and Chapter 10 of Annex 16, Volume 1 for propeller-driven aeroplanes with maximum certificated take-off mass not exceeding 9000 kg.

4.1 SOURCE NOISE ADJUSTMENTS

Source noise adjustment data for propeller driven light aeroplanes may be established by flying the test aeroplane with a range of propeller speeds (for fixed propellers) and torque or manifold air pressure (MAP) values (for variable pitch propellers).

4.1.1 Fixed pitch propellers

For aeroplanes fitted with fixed pitch propellers source noise sensitivity curves are developed from data taken by measuring the noise level for the aeroplane flying at 300 m (985 ft) as described in paragraph 6.5.2 of Annex 16, Volume 1 at the propeller speed for maximum continuous power N_{MCP}. Aeroplanes demonstrating compliance with Annex 16, Chapter 10, should be flown according to paragraph 2.3 of Appendix 6 of Annex 16, Volume 1 such that the aircraft overflys the microphone at the reference height H_{REF} (defined in paragraph 5.1 of Appendix 6), the best rate of climb speed V_y and at the propeller speed, N_{MAX}, corresponding to that defined in paragraph d) of Second Phase of paragraph 10.5.2 of Annex 16. Noise measurements are repeated at two lower propeller speeds typically 200 rpm and 400 rpm lower than N_{MCP} or N_{MAX}. For Chapter 10 aeroplanes these should be flown at speed V_y. The maximum A-weighted noise peak noise level (L_{Amax}) is plotted against propeller helical tip Mach number (M_H) to obtain the curve from which the source noise correction may be derived.

For fixed pitch propellers it is generally not possible via flight tests to separate out the two significant noise generating parameters, helical tip Mach number and power absorbed by the propeller. A sensitivity curve of Mach number versus noise level derived from flight tests of a fixed pitch propeller (either level flyovers or fixed speed climbs) will therefore include within it the effects not only of Mach number but also power. Under these circumstances it is

not appropriate to apply a separate power correction.

4.1.2 Variable pitch propellers

4.1.2.1 For variable pitch propellers the data is taken with the aircraft flying over a range of propeller speeds, typically three, at a fixed torque or MAP in a manner similar to that described in 4.1.1 where N_{MCP} or N_{MAX} would, in this case, be the maximum propeller speed at the maximum permitted torque or MAP. This is repeated for two lower torque or MAP values to establish a carpet plot of maximum A-weighted noise levels against propeller speed and torque, MAP or shaft horse power (SHP).

4.1.2.2 A plot of maximum Aweighted noise level (L_{Amax}), helical tip Mach number (M_H) and torque or MAP is developed which is used to derive the source noise adjustment (L_{Amax}) being the difference between reference and test conditions at the noise certification power.

4.1.2.3 Generally the test and reference engine SHP can be derived from the engine manufacturer's performance curves. However, where such curves are not available a correction should be applied to the manufacturer's published engine SHP (normally presented for a range of engine speeds under ISA and sea level conditions) to establish the engine power level under the test conditions of ambient temperature and air density, as follows:

$$P_T = P_R\,[(T_R/T_T)^{1/2}][(\sigma - 0.117/0.883)]$$

for normally aspirated engines; and

$$P_T = P_R\,[(T_R/T_T)^{1/2}]$$

for turbo-charged engines,

where PT and PR are the test and reference engine powers, TT and TR are the test and reference ambient temperatures, and σ is the air density ratio. Note that in this context reference denotes the reference conditions for which the engine SHP is known.

4.2 TAKE-OFF TEST AND REFERENCE PROCEDURES

In planning a test programme for noise certification under Chapter 10 and Appendix 6, it is helpful to note the differences between test day flight procedures and the standardised take-off reference profile.

4.2.1 The take-off reference profile is used to compute the altitude and speed of the aircraft passing over the microphone on a standard day. The requirements for this profile are contained in paragraph 10.5.2 of Chapter 10. They require that the first segment be computed, using airworthiness approved data, assuming take-off power is used from the brake release point to 15 m (50 feet) above the runway. The second segment is assumed to begin precisely at the end of the first segment, with the aeroplane in a climb configuration (gear up and climb flaps) and operating at the certificated speed for best rate of climb V_y.

A worked example of the calculation of reference flyover height and reference conditions for correction of source noise for aeroplanes certificated according to the standards of Annex 16, Chapter 10 is presented in Appendix (5) of this manual.

4.2.2 Requirements for aeroplane test procedures are contained in two places: Section 10.6 of Chapter 10 and Section 2.3 of Appendix 6. They basically only speak to test tolerances and approval of test plans by certificating authorities.

4.2.3 Figure 13 illustrates the difference between the two. Note that the actual flight test path need not include a complete take-off from a standing condition. Rather, it assumes that a flight path intercept technique is used. As with the turbojet and helicopter standards, the aeroplanes would be flown to intersect the second phase (segment) climb path at the right speed and angle of climb when going over the microphone within 20 per cent of the reference height.

SECTION 5 - EQUIVALENT PROCEDURES FOR HELICOPTERS

The objective of a noise certification demonstration test is to acquire data for establishing an accurate and reliable definition of a helicopter's noise characteristics (see section 8.7 of Annex 16, Volume 1). In addition, the Annex establishes a range of test conditions and procedures for adjusting measured data to reference conditions.

5.1 FLIGHT TEST PROCEDURES

5.1.1 Noise certification guidance

Noise certification of helicopters has been required fairly recently and many applicants may find that the current standards and procedures differ from those that they have used hitherto. The following paragraphs are designed to provide clarification of the requirements as set out in Chapter 8 and Appendix 2 of Annex 16, Volume 1.

5.1.1.1 Helicopter test window for zero adjustment for atmospheric attenuation

5.1.1.1.1 There is currently a "test window" contained in Annex 16, Volume 1 (paragraph 2.2.2 of Appendix 2) which needs to be met before test results are acceptable to certificating authorities. In addition if the test conditions fall within a “zero attenuation adjustment window” (Figure 16) defined as the area enclosed by 2°C, 95% RH; 30°C, 95%RH; 30°C, 35% RH; 15°C, 50% RH; and 2°C, 90% RH, the atmospheric attenuation adjustment of the test data may be taken as zero. That is the terms $0.01[\alpha(i) - \alpha(i)_0]QK$ and $0.01\alpha(i)_0(QK - Q_rK_r)$ from the equation for $SPL(i)_r$ in paragraph 8.3.1 of Appendix 2 of Annex 16, Volume 1, become zero and the adjustment becomes:

$$SPL(i)_r = SPL(i) + 20\log(QK/Q_rK_r)$$

In addition, provided that all the measured points for a particular flight condition are within the “zero attenuation adjustment window” defined in Figure 16 and are within the appropriate height tolerances for flyover of ±9 m (±29.5 ft), for approach ±10 m (±32.8 ft) and the 2 EPNdB limit on the take-off adjustment for height given in paragraph 8.7.4a of Chapter 8 of Annex 16, Volume 1, the

ratios of the reference and test slant distances for the propagation path adjustments may be replaced by the ratios of the reference and test distances to the helicopter when it is over the centre noise measuring point.

The total effect of both simplifications is that the equation of paragraph 8.3.1 of Appendix 2 of Annex 16, Volume 1 becomes:

$$\mathrm{SPL}(i)_r = \mathrm{SPL}(i) + 20\log(\mathrm{HK}/\mathrm{H_rK_r})$$

and the duration adjustment specified in paragraph 8.4.2 of Appendix 2 of Annex 16, Volume 1, becomes:

$$\Delta_2 = -7.5\log(\mathrm{HK}/\mathrm{H_rK_r}) + 10\log(\mathrm{V}/\mathrm{V_r})$$

where HK is the measured distance from the helicopter to the noise measuring point when the helicopter is directly over the centre noise measuring point and $\mathrm{H_rK_r}$ is the reference distance.

5.1.1.2 Helicopter test speed

5.1.1.2.1 There are two requirements on helicopter test speeds. Firstly, the airspeed during the 10 dB-down time period should be close to, ie. within 9 km/h (5 kt), of the reference speed (see 8.7.6 of Volume 1 of Annex 16) to minimize speed adjustments for the three certification conditions of take-off, flyover and approach.

5.1.1.2.2 The second speed requirement applies to the flyover case (see 8.7.7 of Volume 1 of Annex 16). When the absolute wind speed component in the direction of flight exceeds 9 km/h (5 kt) the level overflights shall be made in equal numbers with a head wind component and tail wind component. The objective is to counter the effect of the short duration correction obtained in the downwind direction with the larger one into wind. In steady wind conditions the net effect of flying into and with the wind would be zero.

5.1.1.2.3 The measurement of groundspeed may be obtained by timing the helicopter as it passes over two points a known distance apart on the helicopter track during the overflight noise measurements. These two points should straddle the noise measurement microphone array.

5.1.1.3 Test speed for light helicopters

For the purposes of compliance with Chapter 11 of Annex 16, Volume 1, the helicopter should be flown at test speed Var which will produce the same

advancing blade Mach number as the reference speed in reference conditions given in paragraphs 11.5.1.4 and 11.5.2 b) of Chapter 11 of Annex 16.

The reference advancing blade Mach number M_R is defined as the ratio of the arithmetic sum of the blade tip rotational speed V_{tip} and the helicopter true airspeed V_{REF} divided by the speed of sound, c, at 25 °C (346.1 m/sec) such that:

$$M_R = \frac{V_{TIP} + V_{REF}}{c}$$

The test airspeed V_{AR} is calculated from:

$$V_{AR} = c_T\left(\frac{V_{TIP} + V_{REF}}{c}\right) - V_{TIP}$$

where: c_T is the speed of sound obtained from the onboard measurements of outside air temperature.

Since the ground speed obtained from the overflight tests will differ from that for reference conditions an adjustment Δ_2 of the form:

$$\Delta_2 = 10\log(V_{AR}/V_{REF})$$

will need to be applied. Δ_2 is the increment in decibels that must be added to the measured sound exposure level (SEL).

5.1.1.4 Helicopter test mass

5.1.1.4.1 The mass of the helicopter during the noise certification demonstration (see 8.7.11 of Volume 1 of Annex 16) must lie within the range 90 per cent - 105 per cent of the maximum take-off mass for the take-off and flyover and between 90 per cent - 105 per cent of the maximum landing mass for the approach demonstration. For noise certification purposes the effect of change of mass is to change the test day flight path for take-off and adjustments to the reference flight path should be made for spherical spreading and atmospheric attenuation as described in section 9 of Appendix 2, Annex 16, Volume 1.

5.1.1.4.2 In some cases, such as when the test aircraft weight is restricted to a value somewhat less than the anticipated final certification weight, the applicant may, subject to the approval of the certificating authority, apply specific corrections for weight variations. The applicant may be approved to use a 10 log relationship correction or otherwise determine, by flight test, the

variation of EPNL with weight. In such a case the weights tested should include the maximum allowable test weight.

Note: A similar correction procedure may be acceptable when the certificated weight is increased by a small amount subsequent to the flight tests.

5.1.1.5 Helicopter approach

Section 8.7.10 of Chapter 8 in Annex 16 constrains the approach demonstration to within ±0.5° of the reference approach angle of 6°. Adjustments to the reference approach angle are required to account for spherical spreading effects and atmospheric attenuation as described in section 9 of Appendix 2, Annex 16, Volume 1.

5.1.1.6 Helicopter flight path tracking

Annex 16, Volume 1, Appendix 2, Section 2.3 requires that the helicopter position relative to the flight path reference point be determined and synchronised adequately with the noise data between the 10 dB-down points.

Methods which have been used include:

a) radar or microwave tracking system;

b) theodolite triangulation; and

c) photographic scaling

These techniques may be used singly or in combination. Practical examples of aircraft tracking systems employing one or more of these techniques, are described below. This material is not intended to be an exhaustive list and additional information will be included as more experience is acquired.

5.1.1.6.1 Radar or microwave tracking system

One example of a radar position tracking system is shown in Figure 14. It operates on a principle of the pulse radar with a radar interrogator (receiver/transmitter) located on the aircraft and a radar transponder (reference/station) positioned at each reference station. The elapsed time between the receiver/transmitter pulse and reception of the pulse returned from the reference station transponder is used as the basis for determining the range of each reference station.

This range information together with the known location of the reference stations can be used to obtain a fix on the position of the aircraft in three dimensions. A pulse coding system is employed to minimise false returns caused

by radar interference on reflected signals.

The system performs the following basic functions during noise certification:

a) continuously measures the distance between the helicopter and four fixed ground sites;

b) correlates these ranges with IRIG-B time code and height information and outputs this data to a PCM recorder;

c) converts the aircraft range and height information into X, Y and Z position coordinates in real time; and

d) uses the X, Y, Z data to drive a cockpit display providing the pilot with steering and position cueing.

The accuracy of the co-ordinate calculation depends on the flight path and transponder geometry. Errors are minimised when ranges intersect and the recommended practice is to keep the intersection angle near to 90°. The four transponder arrangements shown in Figure 14 produce position uncertainties from ±1.0 to ±2.0 m.

Some inaccuracies at low aircraft heights can be introduced with the use of microwave systems and the use of a radio-altimeter can reduce the errors. The height data is recorded and synchronised with the microwave.

Helicopter equipment: The distance measuring unit computer and transponder beacon are connected to a hemispherical antenna which is mounted under the fuselage, on the aircraft centreline, as close to the helicopter centre of gravity as possible.

Ground equipment: The four beacons are located on either side of the aircraft track to permit the optimum layout, ie. covering the helicopter with angles between 30° and 150° (90° being the ideal angle).

For example, two beacons can be located in the axis of the noise measurement points at ±500 m of central microphone, another two beacons can be located under track at ±600 m from the central microphone.

5.1.1.6.2 Kine-theodolite system

It is possible to obtain helicopter position data with classical kinetheodolites, but it is also possible to make use of a system composed of two simplified theodolites including a motorised photocamera on a moving platform

reporting site and elevation. These parameters are synchronized with coded time and the identification number of every photograph recorded.

Each 0.1 s site and elevation data are sent by UHF to a central computer which calculates the helicopter position X, Y, Z, versus time for each trajectory.

Photography stations are located at sideline positions, about 300 m from the track, and at 200 m either side of the 3 noise measurement points.

The accuracy of such a system can be ±1.5 m in (X, Y, Z) over the working area.

5.1.1.6.3 Radar / theodolite triangulation

The opto-electronic system shown diagramatically in Figure 15 uses a single optical theodolite to provide azimuth and elevation while range data are obtained from a radar tracking system using a single transponder. Data from these two sources are transferred to a desk top calculator at a rate of 20 samples/second from which three dimensional position fixes can be derived. The system also provides tape start and stop times to the measuring sites, synchronising all tape recording times. Accuracy of the system is approximately ±2.0 m, ±1.0 m and ±2.0 m for horizontal range (x), cross-track (y) and height (z) respectively. Uncertainties associated with determination of the visual glide slope indicator and ground speed are ±0.1° and ±0.5 kt.

5.1.1.6.4 Photographic scaling

The flight path of the helicopter during the noise certification demonstration may be determined by the use of a combination of ground based cameras and height data supplied as a function of time from the on-board radio or pressure altimeters.

In this method three cameras are placed along the intended track such that one is sited close to the centre microphone position and the other two sited close to each of the 10 dBdown points typically 500 m either side of the microphone, depending upon the flight procedure being used. The cameras are mounted vertically and are calibrated so that the image size, obtained as the helicopter passes overhead, can be used to determine the height of the aircraft. It is important that the time at which each camera fires is synchronised with the on-board data acquisition system so that the height of the aircraft as it passes over each of the cameras, can be correlated with the heights obtained from the photographs.

The flight path of the helicopter as a function of distance may be obtained by fitting the aircraft data to the camera heights. The aircraft reference dimension should be as large as possible to maximise photograph image size but should be chosen and used with care if errors in aircraft position are to be avoided. Foreshortening of the image due to main rotor coning (bending of the blades), disc tilt or fuselage pitch attitude if not accounted for will result in over estimates of height, lateral and longitudinal offsets.

By erecting a line above each of the cameras at right angles to the intended track, at a sufficient height above the camera to provide a clear photographic image of both the line and the helicopter, the applicant may obtain the lateral offset of the helicopter as it passes over each of the cameras. This can be done by attaching marks to the line showing the angular distances from overhead at 5° intervals either side of the vertical.

This method may be used to confirm that the helicopter follows a 6°±0.5° glideslope within 10° of overhead the centre microphone as required by Annex 16, Volume 1, Chapter 8, paragraph 8.7.10 and 8.7.8.

Further, from the synchronised times of the helicopter passing over the three camera positions the ground speed can be determined for later use in the duration correction adjustment.

Overall accuracy of the system is ±1.0 per cent of height and ±1.3 per cent of longitudinal and lateral displacements. Mean approach/climb angles and mean ground speed can be determined within ±0.25° and ±0.7 per cent respectively.

5.1.1.7 Atmospheric test conditions

The temperature, relative humidity and wind velocity limitations are contained in Appendix 2 of Annex 16, Volume 1 (see 2.2.2). The parameters are measured at 10 m (33 ft). For adjustment purposes the measured values of these parameters are assumed to be representative of the air mass between the helicopter and the microphones. No calculation procedures based on the division of the atmosphere into layers are required, but such a method of analysis could be accepted by the certificating authority.

5.1.1.8 Procedure for the determination of source noise correction

5.1.1.8.1 For the demonstration of overflight reference noise certification levels off-reference adjustments shall normally be made using a sensitivity curve of PNLTM versus advancing blade tip Mach number deduced from flyovers

carried out at different airspeeds around the reference airspeed; however, the adjustment may be made using an alternative parameter, or, parameters, approved by the certificating authority. If the test aircraft is unable 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 providing that the data cover a range of values of the noise correlating parameter agreed by the certificating authority between test and reference conditions. The advancing blade tip Mach number or agreed noise correlating parameter shall be computed from as measured data using true airspeed, onboard outside air temperature (OAT) and rotor speed. A separate curve of source noise versus advancing blade tip mach number or another agreed noise correlating parameter shall be derived for each of the three certification microphone locations i.e. centreline, sideline left and sideline right. Sidelines left and right are defined relative to the direction of the flight on each run. PNLTM adjustments are to be applied to each microphone datum using the appropriate PNLTM function.

5.1.1.8.2 In order to eliminate the need for a separate source noise correction to the overflight test results the following test procedure is considered acceptable when the correlating parameter is the main rotor advancing blade tip Mach number.

Each overflight noise test must be conducted such that:

a) The adjusted reference true air speed (V_{AR}) is the reference airspeed (V_R) specified in Section 8.6.3 of Chapter 8 of Annex 16, Volume 1, adjusted as necessary to produce the same main rotor advancing blade tip Mach number as associated with reference conditions;

Note: The reference advancing blade tip Mach number (M_R) is defined as the ratio of the arithmetic sum of the main rotor blade tip rotational speed (V_{TIP}) and the helicopter reference speed (V_R) divided by the speed of sound (c) at 25 °C (346.1 m/s) such that:

$$M_R = \frac{V_{TIP} + V_{REF}}{c}$$

and the adjusted reference airspeed (V_{AR}) is calculated from:

$$V_{AR} = c_T\left(\frac{V_{TIP} + V_{REF}}{c}\right) - V_{TIP}$$

where c_T is speed of sound from the onboard measurement of outside air temperature (see Paragraph 6.7).

b) The test true airspeed (V) shall not vary from the adjusted reference true airspeed (V_{AR}) by more than ±5 km/h (±3 kt) or an equivalent approved variation from the reference main rotor advancing blade tip Mach number; and

c) In practice the tests will be flown to an indicated airspeed which is the adjusted reference true airspeed (V_{AR}) corrected for compressibility effects and instrument position errors.

d) The onboard outside static air temperature must be measured at the overflight height just prior to each flyover.

The calculation of noise levels, including the corrections, is the same as that described in Chapter 8 and Appendix 2 of Annex 16, Volume 1, except that the need for source noise adjustment is eliminated. It should be emphasised that in the determination of the duration correction (Δ_2), the speed adjustment to the duration correction is calculated as 10 $\log(V_g/V_{gr})$, where Vg is the test ground speed and Vgr is the reference ground speed.

5.1.2 On board flight data acquisition

5.1.2.1 It is necessary to obtain the values of a variety of flight and engine parameters during the noise measurement period in order to:

a) determine the acceptability of helicopter noise certification flight tests;

b) obtain data to adjust noise data; and

c) to synchronise flight, engine and noise data. Typical parameters would include airspeed, height/altitude, rotor speed, torque, time etc.

5.1.2.2 A number of methods for collecting this information have been employed:

a) manual recording;

b) magnetic tape recording;

c) automatic still photographic recording;

d) cine recording; and

e) video recording.

5.1.2.3 Clearly, when a large number of parameters are required to be

collected at relatively short time intervals, it may not be practicable to manually record the data and the use of one of the automatic systems listed as 5.1.2.2 b) to e) becomes more appropriate. The choice of a particular system may be influenced by a number of factors such as the space available, cost, availability of equipment etc.

5.1.2.4 For systems which optically record the flight deck instruments (5.1.2.2 c) to e)) care must be taken to avoid strong lighting contrast, such as would be caused by sunlight and deep shadow, and reflections from the glass fronts of instruments which would make data unreadable. To avoid this it may be necessary to provide additional lighting to "fill in" deep shadow regions. To prevent reflections from the front of instruments it is recommended that light coloured equipment or clothing on the flight deck is avoided. Flight crews should be required to wear black or dark coloured clothing and gloves.

5.1.2.5 Further, for systems which record the readings of dials it is important that the recording device is as near as possible directly in front of the instruments to avoid parallax errors.

5.1.2.6 Magnetic tape recording

Multi-channel instrumentation tape recorders designed for airborne environments are employed for continuous recording of flight and engine performance parameters. Typical recorders are compact intermediate/wide band and can take both ½" and 1" magnetic tapes with a 24 to 28 Volt DC power requirements. Six tape speeds and both direct and FM recording are available in a tape recorder weighing about 27 kg.

5.1.2.7 Automatic still photographic recording

Photographs of the flight deck instrument panel can be taken using a hand held 35 mm SLR camera with an 85 mm lens and high speed slide film. The indications on the instruments can be read by projecting the slides onto a screen.

5.1.2.8 Cine recording

Cine cameras with a one frame per second exposure rate have been used to acquire flight deck data. Care must be taken in mounting the camera to ensure that all the instruments required to be photographed are within the field of view. Typical film cassettes containing about 2000 frames have been used with a frame counter to allow film changes to be anticipated.

5.1.2.9 Video recording

Flight and engine performance parameters can be recorded with a video camera, although as with cine cameras, care must be taken to ensure that all the instruments required are within the field of view. The recorded information is played back using freeze frame features to obtain individual instrument readings.

5.1.2.10 Time synchronisation of recorded data

The need to synchronise the noise recordings with the on board recorded flight deck data is important. This will involve radio communication between the helicopter and the noise recording positions. Several methods have been used such as noting the synchronization time on a clock mounted on the instrument panel which itself is recorded by the data acquisition system. One such system uses a ground camera which operates a radio transmission which, when received by the helicopter lights two high intensity LED's mounted in an analogue clock attached to the instrument panel.

5.1.3 Procedures for the determination of changes in noise levels

Noise level changes determined by comparison of flight test data for different helicopter model series have been used to establish certification noise levels of modified or newly derived versions by reference to the noise levels of the baseline or "flight datum" helicopter model. These noise changes are added to or subtracted from the noise levels obtained from individual flights of the "flight datum" helicopter model. Confidence intervals of new data are statistically combined with the "flight datum" data to develop overall confidence intervals (see Appendix 1).

5.1.3.1 Modifications or upgrades involving aerodynamic drag changes

Use of drag devices, such as drag plates mounted beneath or on the sides of the "flight datum" helicopter, has proved to be effective in noise certification of modifications or upgrades involving aerodynamic drag changes. External modifications of this type are made by manufacturers and aircraft "modifiers". Considerable cost savings are realised by not having to perform noise testing of numerous individual modifications to the same model series.

Based on these findings it is considered acceptable to use the following as an equivalent procedure:

a) For helicopters to be certificated under Chapter 8 or Chapter 11 of Annex 16, Volume 1, a drag device is used that produces the aerodynamic drag calculated for the highest drag modification or combination of modifications;

b) With the drag producing device installed, a flyover test and takeoff and/or approach test if considered appropriate by the certificating authority, in the case of a Chapter 8 certification, or flyover for the case of a Chapter 11 certification, are performed using the appropriate noise certification reference and test procedures;

c) A relationship of noise level versus change in aerodynamic drag or airspeed is developed using noise data, adjusted as specified in Appendix 2 or 4 of Annex 16, Volume 1, of the "flight datum" helicopter and of the "high drag" configuration;

d) The actual airspeed of the modification to be certificated is determined from performance flight testing of the baseline helicopter with the modification installed; and

e) Using the measured airspeed of the modification, certification noise levels are determined by interpolation of the relationship developed in c) above.

5.1.4 Temperature and Relative Humidity Measurements

5.1.4.1 Temperature and relative humidity measurements as defined in paragraph 2.2.3 of Appendix 2, Annex 16, Volume 1, are required to be made at a height of 10 m (33 ft) above the ground. The measured values are used in the adjustment of the measured one-third octave band sound pressure levels to account for the difference in the sound attenuation coefficients in the test and reference atmospheric conditions as given in paragraph 8.3.1 of Appendix 2, Annex 16, Volume 1. The distances QK and Q_rK_r in the equations of paragraph 8.3.1 refer to the distances between positions on the measured and reference flight paths corresponding to the apparent PNLTM position and the noise measurement point.

5.1.4.2 As a consequence the procedure assumes that the difference between the temperature and relative humidity at 10 m and the PNLTM position is zero or small and that the atmosphere can be represented by the values measured at 10 m (33 ft) above the ground in the vicinity of the noise measurement point. Data obtained from European and U.S. certification tests over a number of years, and records provided by the U.K. Meteorological Office, have confirmed this assumption is valid over a wide range of meteorological conditions.

5.1.4.3 Noise certification measurements made under test conditions where significant changes in temperature and/or relative humidity with height are

expected, particularly when a significant drop in humidity with altitude is expected, should be adjusted using the average of the temperature and relative humidity measured at 10 m (33 ft) and at the height associated with the PNLTM point in order to eliminate errors associated by use of data measured at 10 m (33 ft) only. Such special conditions might be encountered in desert areas shortly after sunrise where the temperature near the ground is lower, and the relative humidity considerable higher, than at the height associated with the PNLTM point. Except for tests made under such conditions experience from noise certification tests over many years clearly indicates that the calculations of paragraph 8.3.1 of Appendix 2 of Annex 16, Volume 1, can be based on meteorological data measured at 10 m (33 ft) only.

5.1.4.4 Paragraph 2.2.2 of Appendix 2, Annex 16, Volume 1 limits testing to conditions where the sound attenuation rate in the 8 kHz one-third octave band is not more than 12 dB/100 m. If, however, the dew point and dry bulb temperature are measured with a device which is accurate to within ±0.5°C it has been found acceptable by certificating authorities to permit testing in conditions where the 8 kHz sound attenuation rate is not more than 14 dB/100 m.

5.1.4.5 Testing of light helicopters outside Chapter 11 temperature and humidity limits

With the approval of the certificating authority it may be possible to conduct testing of light helicopters outside the test environment specified in paragraph 2.2 of ICAO Annex 16, Volume 1, Appendix 4, provided the test environment is within the temperature and relative humidity limits specified in paragraph 2.2 of ICAO Annex 16, Volume 1, Appendix 2. In such circumstances it will be necessary to conduct a one-third octave band analysis of a noise recording of each overflight. The measured value of SEL shall be corrected from the test values of temperature and humidity measured according to paragraph 2.2.2 of ICAO Annex 16, Volume 1, Appendix 4, to the reference conditions defined in paragraph 11.5.1.4 of ICAO Annex 16, Volume 1, Chapter 11. The correction procedure shall be similar to that defined in paragraph 8.3.1 of ICAO Annex 16, Volume 1, Appendix 2 with the propagation distances QK and Q_rK_r replaced by H, the height of the test helicopter when it passes over the noise measurement point and the reference height, 150 m, respectively.

5.1.5 Anomalous Test Conditions

5.1.5.1 Annex 16, Volume 1, Appendix 2, Paragraph 2.2.2(f) requires that

the tests be conducted under conditions that no anomalous meteorological conditions exist. The presence of anomalous atmospheric conditions can be determined to a sufficient level of certainty by monitoring the outside air temperature (OAT) using the aircraft instruments. Anomalous conditions which could impact the measured levels can be expected to exist when the OAT at 150 m (492 ft) is 2°C (3.2°F) or more than the temperature measured at 10 m (33 ft) above ground level. This check can be made in level flight at a height of 150 m (492 ft) within 30 minutes of each noise measurement.

5.1.5.2 Since the actual heights associated with the PNLTM points will not be known until the analysis is made, measurements of temperature and relative humidity can be made at a number of heights and the actual value determined from a chart of temperature and relative humidity versus height. Alternatively since the influence of height is small, measurements at a fixed height, in the order of 120 m (400 ft) and 150 m (492 ft) depending on the flight condition and agreed with the certificating authority prior to the tests being conducted can be used.

5.1.5.3 If tests are adjusted using the “average” of the temperature and relative humidity measured at 10 m (33 ft) and the height association with the PNLTM point described in 5.1.4.4, the provisions of 5.1.5.1 do not apply. This is because the impact of any anomalous meteorological conditions are taken into account by using the average of the temperature and relative humidity at 10 m (33 ft) and the height associated with the PNLTM point.

SECTION 6 - EVALUATION METHODS

Several methods used to resolve difficulties encountered during the measurement and analysis of aircraft noise data have been developed. Some of these procedures are applicable to all aircraft types whereas others have limited application to one or more. This section presents these evaluation methods and describes specific procedures which have been approved to deal with:

a) spectral irregularities which are not related to the aircraft noise sources;

b) ambient noise levels both acoustic and electrical;

c) the establishment and extension of data bases;

d) the use of inertial navigation systems for aeroplane flight path measurements;

e) integrated analysis of noise data;

f) computation of EPNL by the integrated method of adjustment; and

g) calculation of the speed of sound.

6.1 SPECTRAL IRREGULARITIES

Tone corrections are required for tones or irregularities in the spectra of aeroplane noise. Irregularities which occur in measured spectra due to interference effects caused by reflection of sound from the ground surface or by perturbations during the propagation of the noise from the aeroplane to the microphone need to be identified so that tone corrections are not applied to spectral characteristics which are not related to the aeroplane noise source. As specified in paragraph 4.3.1 of Appendix 2 of Annex 16, Volume 1, narrow band analysis is one recommended procedure for identifying these false tones. Other methods of identification that have been approved for use in certification are included in Appendix 2 of this manual. However, the effect of these spectral irregularities are not normally removed from data from propeller-driven aeroplanes or helicopters since they are difficult to differentiate from engine and propeller or rotor associated tones.

6.2 AMBIENT NOISE LEVELS

Ambient noise levels including background acoustic noise levels and electronic noise from measuring and analysis equipment can mask noise levels from aeroplanes over parts of the frequency range of interest for effective perceived noise level calculations. The effects of ambient noise may be removed by use of an approved procedure such as described in Appendix 3.

6.3 ESTABLISHMENT AND EXTENSION OF DATA BASES

6.3.1 Noise certification levels may be determined from a number of repeat noise measurements, at least six, at the same engine power (transmitted power for helicopters), height, speed and configuration at each of the reference noise measurement positions. The noise measurements are adjusted to reference conditions and the mean value and 90 per cent confidence interval obtained in accordance with Annex 16, Volume 1. As an alternative, aircraft may be flown over a range of noise correlating parameters (μ). In the case of aeroplanes the correlating parameter may be engine power setting and/or helical tip Mach number for propeller driven aeroplanes. For helicopters the parameter may be power setting, advancing blade tip Mach number, speed or any other agreed parameter. At least six flights are needed to establish the noise level versus the relevant correlating parameter relationship covering the range relevant to both the prototype and derived aircraft for each of the reference noise measurement sites. Provided that the 90 per cent confidence interval limit of not greater than ±1.5 EPNdB (or ±1.5 dBA as appropriate) is satisfied, as calculated in Appendix 1 of this manual, the noise certification levels may be obtained by entering the curve of noise level versus correlating parameter (μ) at the appropriate reference μ.

6.3.2 In some areas an extrapolation of the data field may be approved but care must be taken to ensure that the relative contributions of the component noise sources to the effective perceived noise level, sound exposure level or A-weighted noise level as appropriate, remains essentially unchanged and that a simple extrapolation of noise/correlating parameter curves can be made.

6.3.3 For propeller driven aeroplanes a change in propeller and/or powerplant may necessitate further flight tests to establish a revised noise-power-distance relationship.

6.4 TEST ENVIRONMENT CORRECTIONS

6.4.1 The atmospheric conditions specified in Annex 16, Volume 1, section

2.2.2(b), (c), (d) and (e) of Appendix 2 require the measurement of ambient air temperature and relative humidity profiles during noise certification tests, to ensure that the temperatures, relative humidities and corresponding atmospheric sound absorption coefficients do not deviate from the specified limits over the whole noise path between ground and aeroplane. Ordinarily, profile measurements are recorded by balloon, instrumented aeroplane, or other similar method during flight testing, in order to ensure that the criteria are met.

6.4.2 At the discretion of the certificating authority atmospheric profile measurements of ambient air temperature and relative humidity may be made by instruments mounted on the test aeroplane, and may be considered sufficient to determine compliance with the criteria specified in section 2.2.2(b), (c), (d) and (e) of Annex 16, Volume 1, Appendix 2.

6.5 INERTIAL NAVIGATION SYSTEMS FOR AEROPLANE FLIGHT PATH MEASUREMENT

6.5.1 Criteria for the measurement of aeroplane height and lateral position relative to the intended track are described in section 2.3 of Appendix 2 of Annex 16 Volume 1. This section indicates that the method used should be independent of normal flight instrumentation. Since the development of this requirement, other tracking systems (inertial navigation systems (INS) and microwave systems) which have a high degree of accuracy have been installed in aeroplanes and consequently have been accepted by several certificating authorities for use during noise certification. However, it is important that any inherent drift in the system is regularly determined and the system calibrated. For this purpose ground based cameras can be used to determine the position of an aeroplane relative to them both laterally and in terms of height. The calibration should be undertaken sufficiently frequently to retain the accuracy specification of the system.

6.5.2 The accuracy of such systems must be acceptable to the certificating authority.

6.6 COMPUTATION OF EPNL BY THE INTEGRATED METHOD OF ADJUSTMENT

6.6.1 Section 9.1 of Annex 16, Appendix 2 provides for the use of the "simplified" or "integrated" method for adjusting measured noise data to reference day conditions. The "integrated" procedure may be applied to

measured data at the flyover, lateral, and approach noise measurement points. The "integrated" adjustment method consists of applying all data adjustments to each measured set of sound pressure levels obtained at 0.5 s intervals to identify equivalent reference average sound pressure levels which are used to compute EPNL's consistent with values which would be obtained under reference conditions. For complete acoustic consistency the adjustment is only applicable if evaluated for identical pairs of noise emission angle (θ) relative to the flight path and noise elevation angle (ψ) relative to the ground for both the measured (test) and corrected (reference) flight paths. While this requirement may be satisfactorily approximated for the flyover and approach noise measurements it can be shown that it is not possible to retain identical pairs of angles when lateral noise measurement adjustments are necessary. Therefore when lateral noise measurement adjustments are made by the "integrated" method, the geometric conditions, of identical noise emission angle should be maintained for test and reference flight paths while the corresponding differences between test and reference elevation angles should be minimised. The slight difference that will occur between test and reference elevation angle will have negligible effect on the corrected EPNL value.

6.6.2 This section describes an integrated adjustment method that is applicable for use when the aeroplane is operated at constant conditions (flight path and power) during the noise measurement period.

6.6.3 Test aircraft position

6.6.3.1 The "integrated" method for adjustment of measured noise-level data to reference conditions requires acoustic and aeroplane performance data at each 0.5 s time interval during the test flights. These data include aeroplane position relative to a three-dimensional (X, Y, Z) co-ordinate system, 1/3-octave-band sound pressure levels SPL(i,k), and time (t_k) at the midpoint of each averaging time period relative to a reference time. Additionally, aeroplane performance parameters, the measurement microphone locations, and temperature and humidity is required for each flyover.

6.6.3.2 The aircraft height Z is measured above the reference X-Y plane, generally taken to be the ground plane, with the measurement microphone 1.2 m above this reference plane. The average test flight path is assumed to be a straight line (except when power reduction is used during the flyover measurement) and the time-correlated aeroplane-position data are used to determine time of overhead (t_{oh}), the test overhead height (h_{To})*, and the test minimum distance (d_{Tm}) from the test flight path to the microphone location

($K(X_{TM}, Y_{TM}, Z_{TM})$).

*Note: For emphasis the subscript "T" is used here for test conditions. Annex 16 uses un-subscripted symbols for test conditions.

6.6.3.3 Using the test data directly or by geometric analysis of the relation between the average straight line flight path and the minimum distance line from K_T to R_T (X_{RT}, Y_{RT}, Z_{RT}) as shown in Figure 10 the minimum distance becomes:

$$d_{Tm} = [(X_{RT} - X_{TM})^2 + (Y_{RT} - Y_{TM})^2 + (Z_{RT} - Z_{TM})^2]^{1/2} \quad (1)$$

6.6.4 Sound-propagation times and sound-emission angles

6.6.4.1 The test sound propagation time (Δt_{pk}) is identified with the data record time (t_k), the noise emission time (t_{ek}), the aeroplane position (A_k) at time (t_{ak}), and the averaging time (t_{Av}) through the relationships:

$$t_k = t_{ak} - \tfrac{1}{2}\, t_{Av} \quad (2)$$

$$t_{ek} = t_k - \Delta t_{pk} \quad (3)$$

$$\Delta t_{pk} = K_T Q_{ek} / c_T \quad (4)$$

where c_T is the speed of sound for the average absolute temperature of the air between the surface (T_S) and the height of the aeroplane (T_A) (see Paragraph 6.7, where $T = (T_S + T_A)/2$).

6.6.4.2 Using the geometric relationships of Figure 11, the minimum distance from Equation (1), the test distance $Q_{ek}R$, and defining the time difference B equal to $t_{Tm} - t_k$ yields the following expression for the test-flightpath sound-propagation times:

$$\Delta t_{Tpk} = [1/(c_T^2 - V_T^2)] \times \{BV_T^2 + [(c_T^2 - V_T^2)\,(d_{Tm})^2 + (Bc_T V_T)^2]^{1/2}\} \quad (5)$$

where V_T is the average true air speed of the test aeroplane along the flight path.

6.6.4.3 Similarly the test soundemission angle is defined as:

$$\theta_{ek} = \sin^{-1}(d_{Tm}/d_{Tpk}), \text{ or } \theta_{ek} = \sin^{-1}[d_{Tm}/(\Delta t_{Tpk})\,(c_T)] \quad (6)$$

6.6.5 Aircraft reference flight path

6.6.5.1 The geometry of the reference flight path is essentially similar to that shown in Figure 10, however, the following differences exist. The reference

flight path is directly over the runway centerline (ie. $Y_{DEV} = 0$). For the take off and approach flyovers, the measurement station is on the runway centerline (ie. $Y_{Rr} = Y_{rM}$); for lateral noise measurements, $(Y_{Rr} - Y_{rM})$ equals the reference lateral displacement of the measurement station.

Note (1): The subscript r is used to denote reference conditions.

Note (2): The reference microphone location (K_r) for flyover or lateral noise measurements is usually at the same coordinates as for the test location (K_T), ie. $(X_{TM}, Y_{TM}, Z_{TM}) = (X_{rM}, Y_{rM}, Z_{rM})$.

6.6.5.2 The reference flight path may be geometrically specified relative to the reference microphone location (K_r) by using the measurement station lateral distance, the height overhead (h_{ro}) and the flight path inclination angle (γ_r). These values are equated to the minimum distance (d_{rm}) from K_r by the following:

$$d_{rm} = [h_{ro}^2 \cos^2\gamma_r + (Y_{Rr} - Y_{rM})^2]^{1/2}, \text{ or}$$

$$d_{rm} = [(X_{Rr} - X_{rM})^2 + (Y_{Rr} - Y_{rM})^2 + (Z_{Rr} - Z_{rM})^2]^{1/2} \quad (7)$$

6.6.5.3 The basic acoustic assumption relating the test and reference flight conditions is that the three dimensional acoustic emission angles (θ_{ek} and θ_{erk}) for each test record time (t_k) and the corresponding reference time (t_{rk}) are equal. Using Equation (6) and this equality the test sound pressure levels, SPLT(i,k), for each of the i-th frequency bands, are adjusted for spherical spreading and atmospheric absorption over the acoustic path lengths by the equation:

$$SPL_r(i,rk) = SPL_T(i,k) - 20\log(d_{rpk}/d_{Tpk}) - [(a_{i0})d_{rpk} - (a_i)d_{Tpi}] \quad (8a)$$

where a_{i0} and a_i are the reference and test day sound attenuation coefficients respectively, or, when the test and reference flight path minimum distances are used, by the equation:

$$SPL_r(i,rk) = SPL_T(i,k) - 20\log(d_{rm}/d_{Tm}) - [(a_{i0})d_{rm} - (a_i)d_{Tm}]\text{cosec}\theta_{ek} \quad (8b)$$

6.6.6 Time interval computation

6.6.6.1 In addition to the above adjustments of the test data for spherical spreading and atmospheric absorption it is necessary to make an adjustment for the change in the time increment trk used in the computation of EPNL. Since the time increments are not equal to the 500 ms test measurement time increments

when adjusted by the "integrated" method, successive aeroplane position reference times (t_{rk} and $t_{r(k+1)}$) occur after the time reference (t_{rek}) at the sound emission point (Figure 11). The average time increment to be used in the EPNL computation is:

$$\delta t_{rk} = [\Delta t_{rk} + \Delta t_{r(k+1)}]/2 \quad (9)$$

where the reference time interval (Δt_{rk}) between data records is $\Delta t_{rk} = t_{r(k+1)} - t_{rk}$. and using the relationship between sample times, sound emission times, and sound propagation times the reference interval becomes:

$$\delta t_{rk} = [t_{re(k+1)} - t_{rek}] + [\Delta t_{rp(k+1)} - \Delta t_{rpk}] \quad (10)$$

6.6.6.2 This time interval reflects the time for the aeroplane to travel at test and reference speeds (V_T and V_r) from one sound emission point to the next and also the effect of differences between test and reference minimum distances (d_{rm} and d_{Tm}) as well as sound speeds (c_r and c_T). These factors are expressed explicitly by arranging Equation (10) as follows:

$$\Delta t_{rk} = (d_{rm}/d_{Tm})\{(V_T/V_r)[0.5 - (\Delta t_{Tp(k+1)} - \Delta t_{Tpk})] + (c_T/c_r)(\Delta t_{Tp(k+1)} - \Delta t_{Tpk}) \quad (11)$$

6.6.7 Adjusted effective perceived noise level

After the sound pressure levels have been adjusted using Equation (8) the tone corrections are calculated following section 4.3 of Appendix 2, Annex 16 and using the noy weighting and the procedure for calculating perceived noise level (Section 4.2, Appendix 2, Annex 16) the reference PNLT's are available for the times tr1 to trn which include the first and last 10 dB-down times. These values and the adjusted average time increment, Equation (9), are combined to compute the adjusted EPNL as follows:

$$\mathrm{EPNL} = 10\log\left[\left(\frac{1}{T_0}\right)\sum_{k=1}^{n}\left(10^{0.1\mathrm{PNLT}_k}\right)\left(\delta t_{rk}\right)\right]$$

where the reference time (T_0) is 10 s and the summation is started by setting $\Delta t_{r(1-1)} = \Delta t_{r(2-1)}$ so that $\delta t_{r(1-1)} = \Delta t_{r1}$. The summation is terminated by assuming $\Delta t_{rn} = \Delta t_{r(n-1)}$ giving $\delta t_{rn} = \Delta t_{rn} = \Delta t_{r(n-1)}$.

6.7 CALCULATION OF THE SPEED OF SOUND

For the purposes of noise certification the value of the speed of sound, c,

shall be calculated from the equation taken from ISO 9613-1: 1993(E):

$$c = 343.2(T/T_0)^{1/2} \text{ metres/sec (i.e. } 1125.9(T/T_0)^{1/2} \text{ feet/sec)}$$

where $T_0 = 293.15$ °K and T is the absolute ambient air temperature.

SECTION 7 - MEASUREMENT AND ANALYSIS EQUIPMENT

Current technology noise recording and analysis equipment employing digital techniques which offer greater flexibility and precision than before are not catered for in the specification of equipment used in noise certification and described in Annex 16, Volume 1, Appendix 2, Section 3.

This section describes new instrumentation standards which have been approved by CAEP Working Group 1 to replace the existing Section 3 of Appendix 2 of Annex 16, Volume 1 and thereby enable the increasing use of digital instrumentation.

This section will be removed from the Environmental Technical Manual when it is adopted into the Annex.

This section has already adopted into CCAR-36-R1, see § A36.3, Measurement of Airplane Noise Received on the Ground.

SECTION 8 - CONTROL OF NOISE CERTIFICATION COMPUTER PROGRAM SOFTWARE AND DOCUMENTATION RELATED TO STATIC-TO-FLIGHT PROJECTION PROCESSES

8.1 GENERAL

8.1.1 Procedures for computer program software control shall be developed, approved by the certificating authority, and maintained and adhered to by each applicant utilizing "static-to-flight equivalencies (SFE's)".

8.1.2 The procedures shall consist of four key elements which, when implemented by the noise certification applicant, shall result in documentation which properly describes and validates the applicable SFE noise certification computer program and data output. Throughout the development of a given aeroplane type, adherence to these procedures will enable critical computer programs to be tracked in order to verify that the initial software design has not been changed without substantiation.

8.1.3 The four key elements of configuration index, control procedures, design description and verification process are described below.

8.2 SOFTWARE CONTROL PLAN

8.2.1 Configuration index

A configuration index shall be established for each unique SFE software system. It will include all applicable elements of the software system and provide historic tracking of documents and software under control. Where appropriate, the index may be maintained in a general data base.

8.2.2 Software control plan

8.2.2.1 A procedure for SFE software change management shall be established that includes the baseline design identification, a software change control system and a method of reviewing and auditing software changes and maintaining a status accounting of changes.

8.2.2.2 Control of software changes shall be maintained by establishing baselines within the verification process (see 8.2.4) and documenting modifications to the baseline case that result from program coding changes.

Review and auditing procedures will be established within the verification process that allow the validity of the program coding changes for the "modified" configuration to be assessed relative to the "baseline" configuration.

8.2.2.3 The configuration index shall be updated to reflect, historically, the changes made to the software system.

8.2.3 Design description

A technical description of the methods used to accomplish the SFE certification shall be provided; including an overview and a description of the software system design to accomplish the technical requirements. The software design description should include the program structure, usage of subroutines, program flow control and data flow.

8.2.4 Verification process

The validation procedure for the SFE software system, or modifications to it, shall include a process to verify that the calculations described in the documentation are being properly performed by the software. The process may include hand calculations compared to computer output, stepwise graphical displays, software audits, diagnostic subroutines that generate output of all relevant variables associated with the modifications, or other methods to establish confidence in the integrity of the software. The process results shall be monitored and tracked relative to software calculation changes.

8.3 APPLICABILITY

Although the software control plan is applicable to all SFE-specific computer program software and documentation established through the specific procedures and processes of each applicant, it may not be necessary to review and audit ancillary software (such as, but not limited to, subroutines dealing with atmospheric absorption rates, noy calculations, tone corrections) for each main program source code change.

SECTION 9 - GUIDELINES FOR NOISE CERTIFICATION OF TILTROTOR AIRCRAFT

Guidelines have been developed for the noise certification of tiltrotor aircraft. These are presented as an attachment to ICAO Annex 16, Volume 1. To help in the understanding of these guidelines and to assist in their application background information is presented in Appendix 6.

REFERENCES

1. Jet mixing noise: comparison of measurement and theory.
   B.J. Tester and V.M. Szewczyk, AIAA Paper 79-0570.

2. 1974 Proceedings of the Second Inter-Agency Symposium on University Research in Transportation Noise, Volume 1, Pages 50-58, On Noise Produced by Subsonic Jets.
   J. Laufer, R.E. Kaplan and W.T. Chu.

3. Airframe Noise Prediction Method.
   M.R. Fink, USA DOT Report FAA-RD-77-29 dated March 1977.

4. SAE ARP 866A: 1975 Standard Values of Atmospheric Absorption as a Function of Temperature and Humidity.

5. SAE ARP 876D: 1993 Gas Turbine Jet Exhaust Noise Prediction.

6. SAE AIR 1672B: 1983 Practical Methods to Obtain Free Field Sound Pressure Levels from Acoustical Measurements over Ground Surfaces.

7. SAE AIR 1846-1984: Measurement of Noise from Gas Turbine Engines During Static Operation.

8. SAE AIR 1905-1985: Gas Turbine Co-axial Exhaust Flow Noise - Methods of Prediction Considered for Inclusion in SAE ARP 876.

9. ESDU Item 80038, Amendment A: The Correction of Measured Noise Spectra for the effects of Ground Reflection.

FIGURES

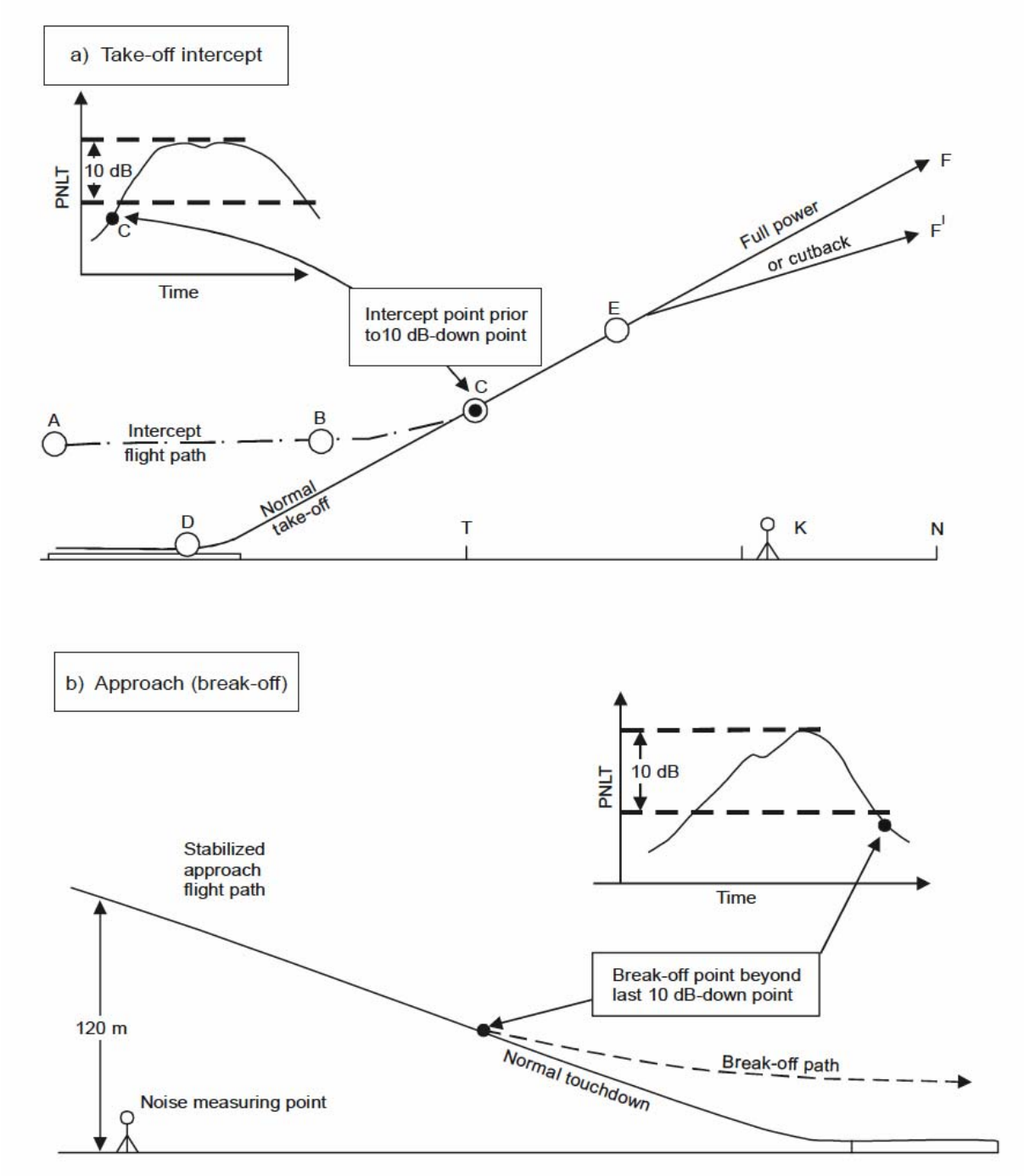


Figure 1 Flight Path Intercept Procedures

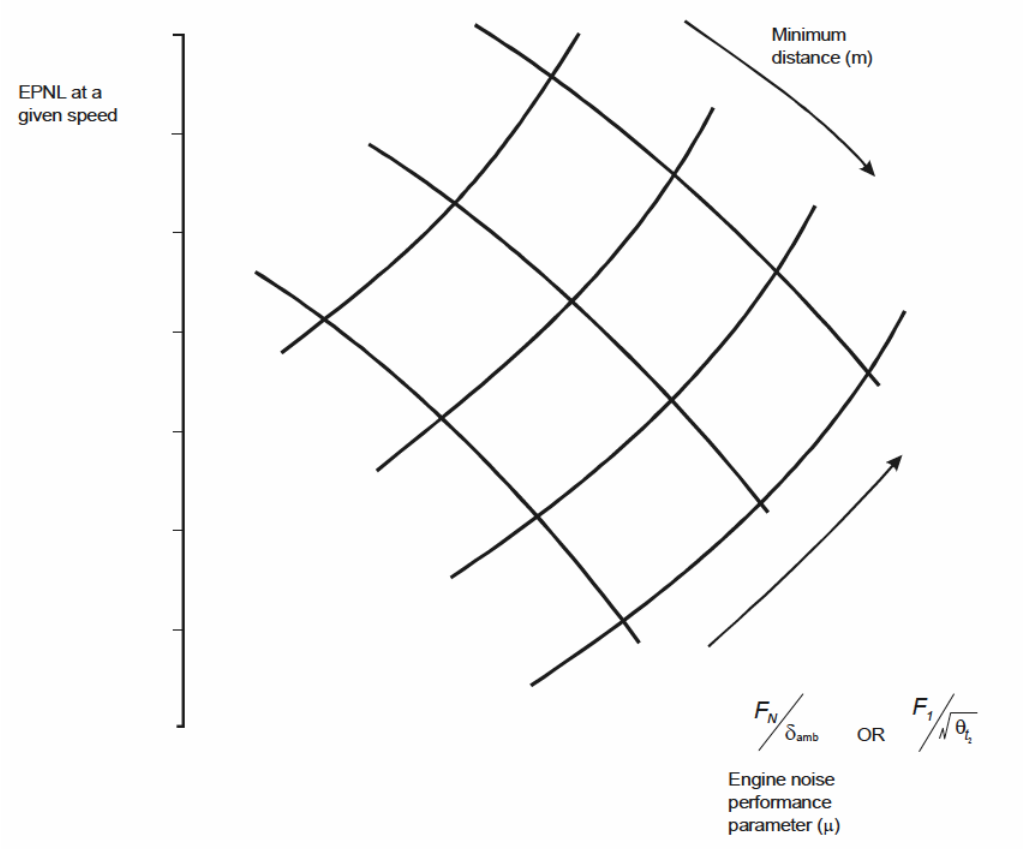


Figure 2 Form of NPD plot for turbo-jet or turb-fan powered aeroplanes

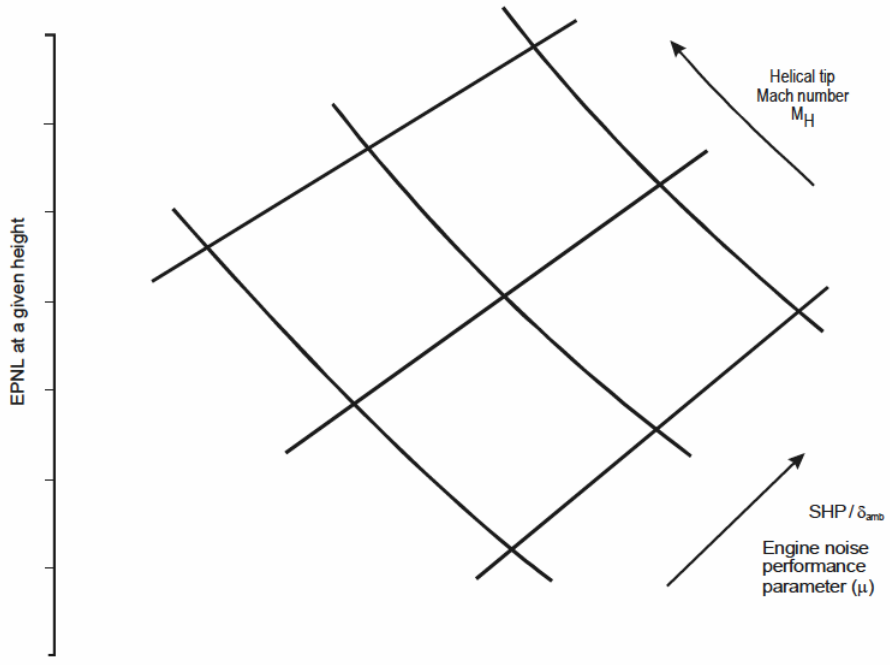


Figure 3 Form of NPD plot for propeller driven heavy aeroplanes

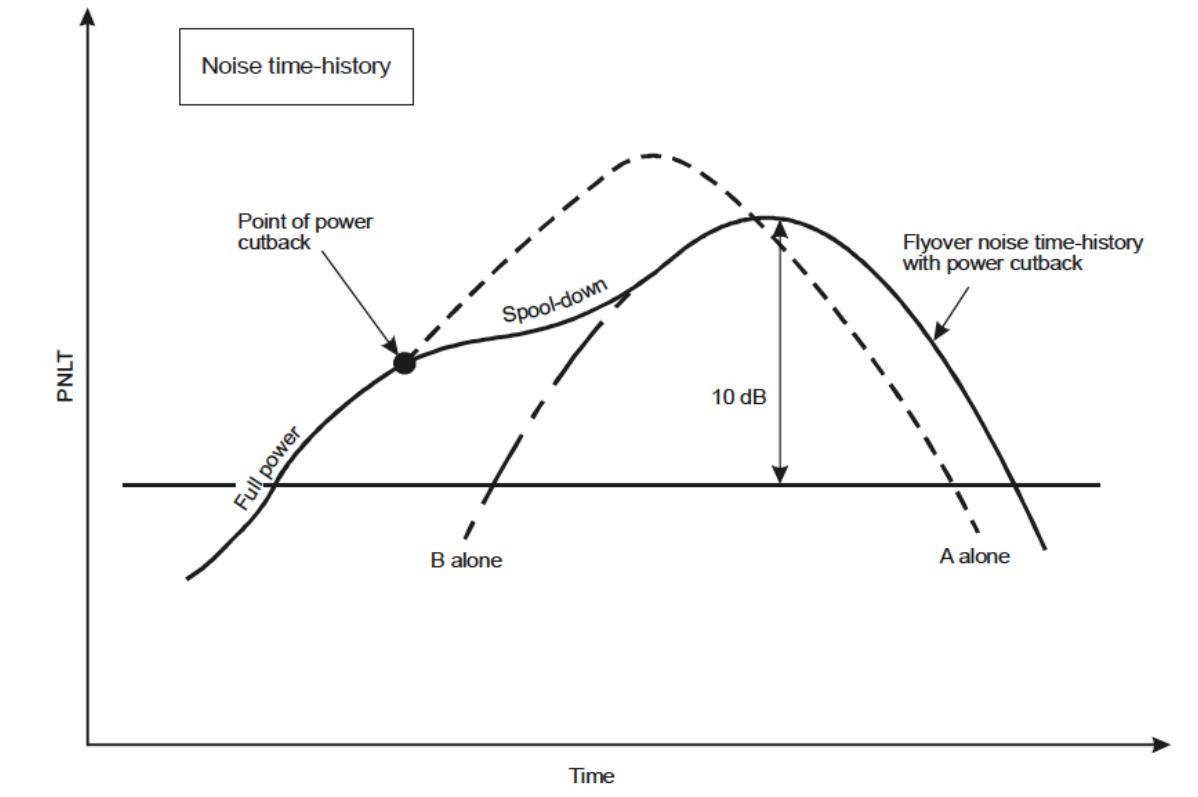


Figure 4 a). Computation of cutback take-off noise level from constant power tests

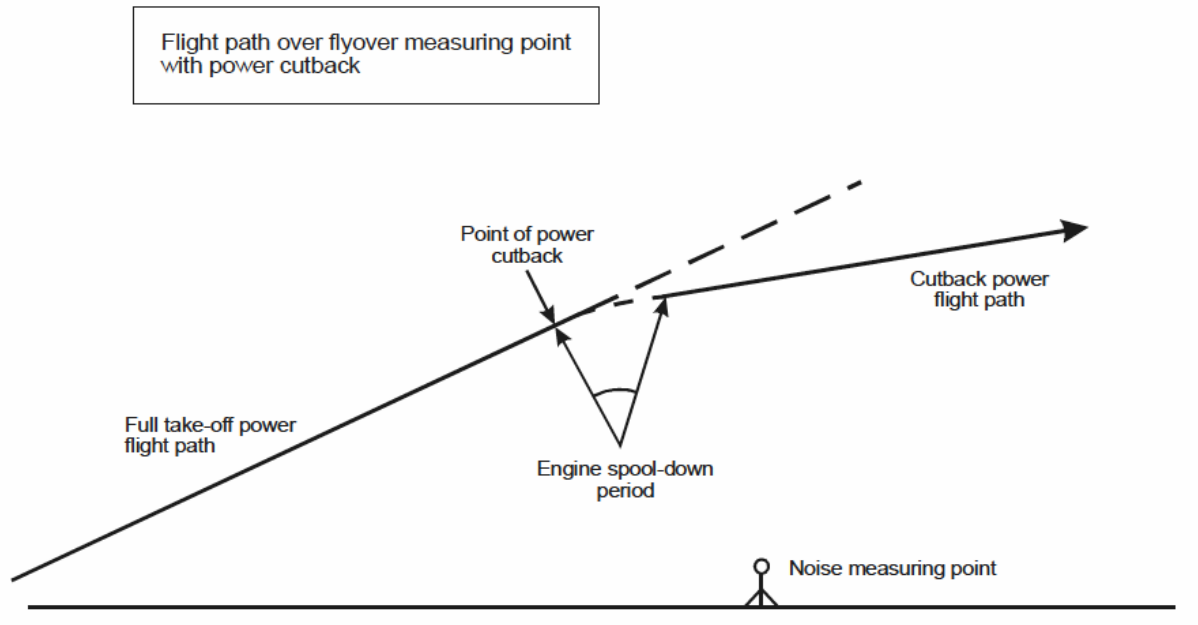
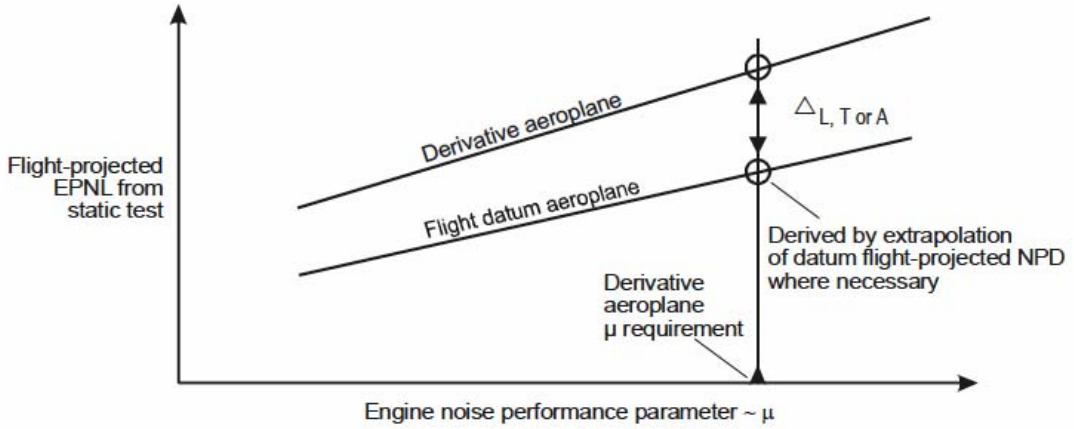


Figure 4 b). Computation of reduced thrust take-off noise level from constant thrust tests



Definitions

$\triangle_L$ = Difference between flight datum and derivative aeroplane EPNL at the power requirement of the derivative aeroplane at the lateral condition.

$\triangle_T$ = Difference between flight datum and derivative aeroplane EPNL at the power requirement and altitude of the derivative aeroplane at the take-off condition.

$\triangle_A$ = Difference between flight datum and derivative aeroplane EPNL at the power requirement of the derivative aeroplane at the approach condition.

Limitations

(i) $|\triangle_L| + |\triangle_T| + |\triangle_A|$ shall not exceed 5 EPNdB.

(ii) $\triangle_L$, $\triangle_T$ or $\triangle_A$ shall not exceed ± 3 EPNdB individually.

Figure 5. Limitation on the use of static test where no valdating flight test data exist

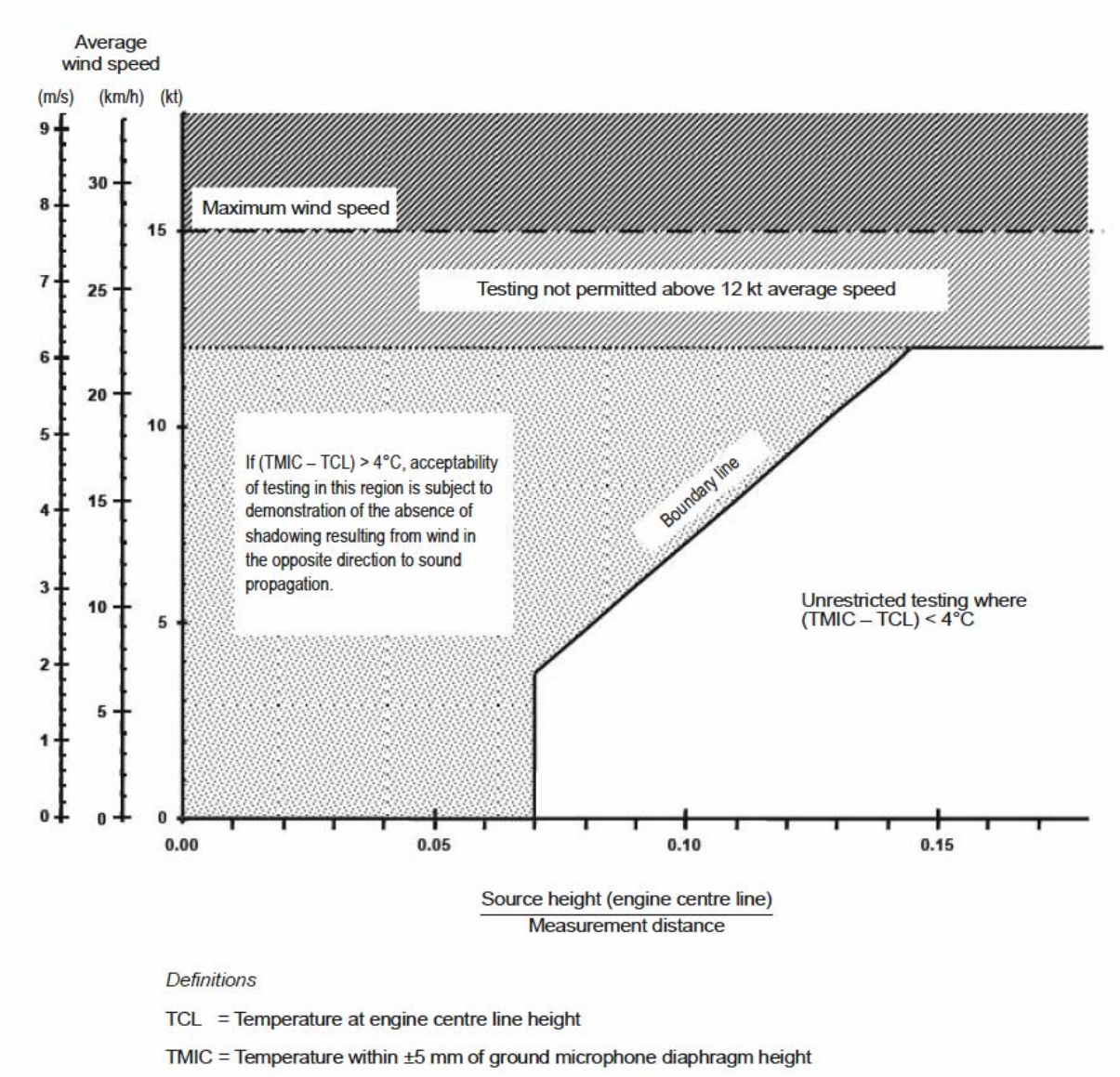


Figure 6. Weather criteria for use with ground microphone installations

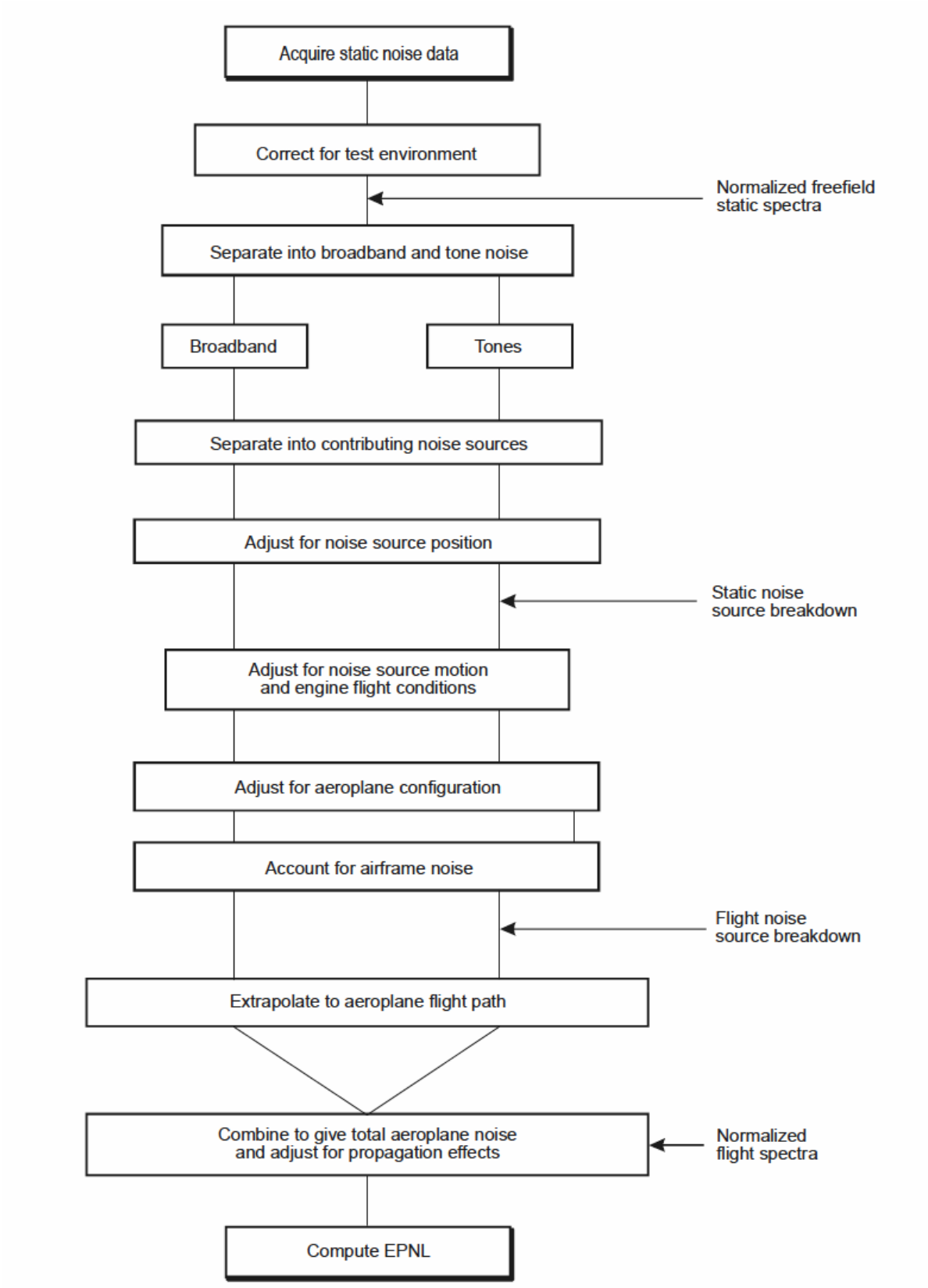


Figure 7. Generalised projection of static engine data to

aeroplane flight condition

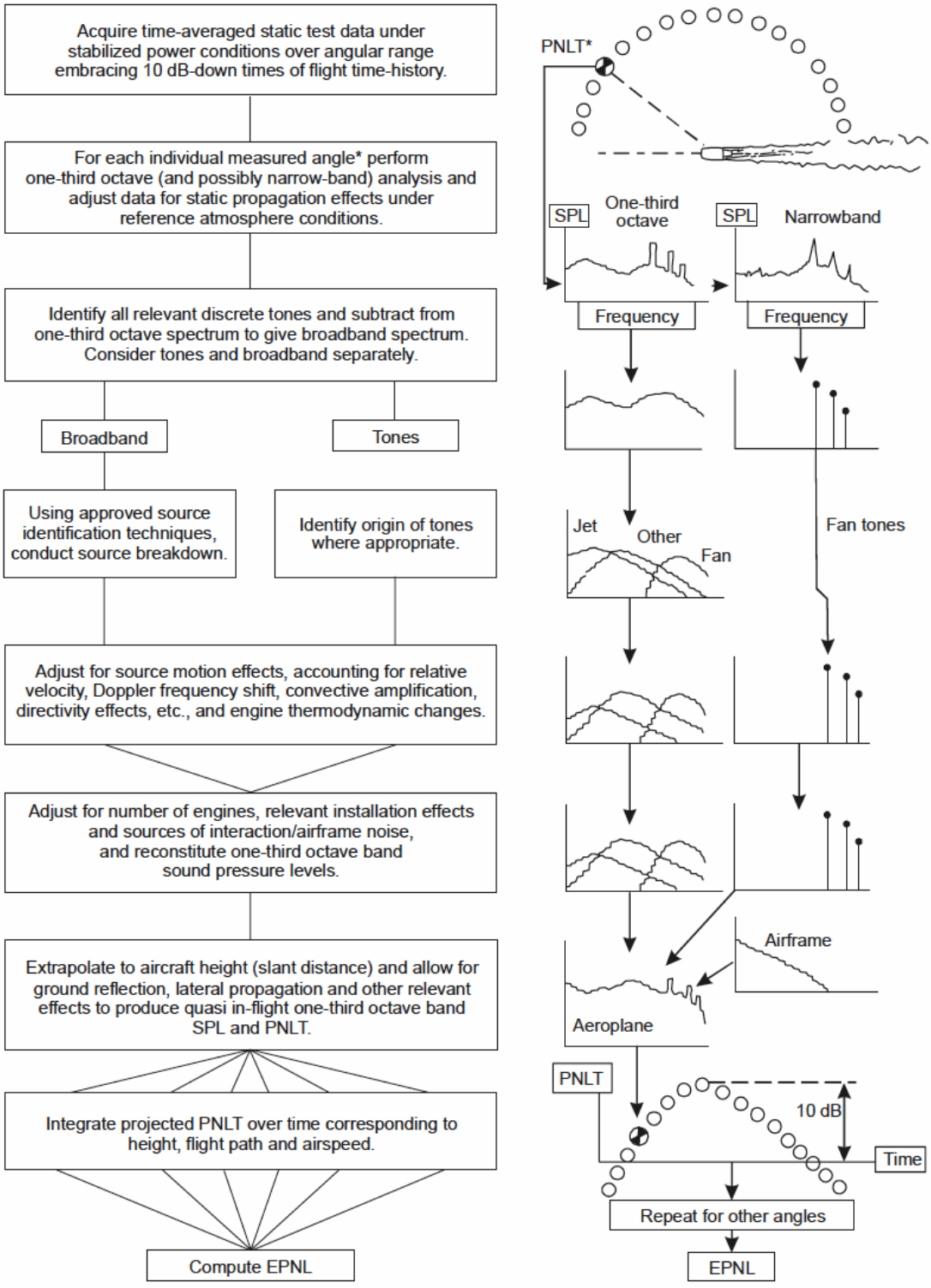


Figure 8. Example procedure for projection of static engine data to aeroplane flight conditions

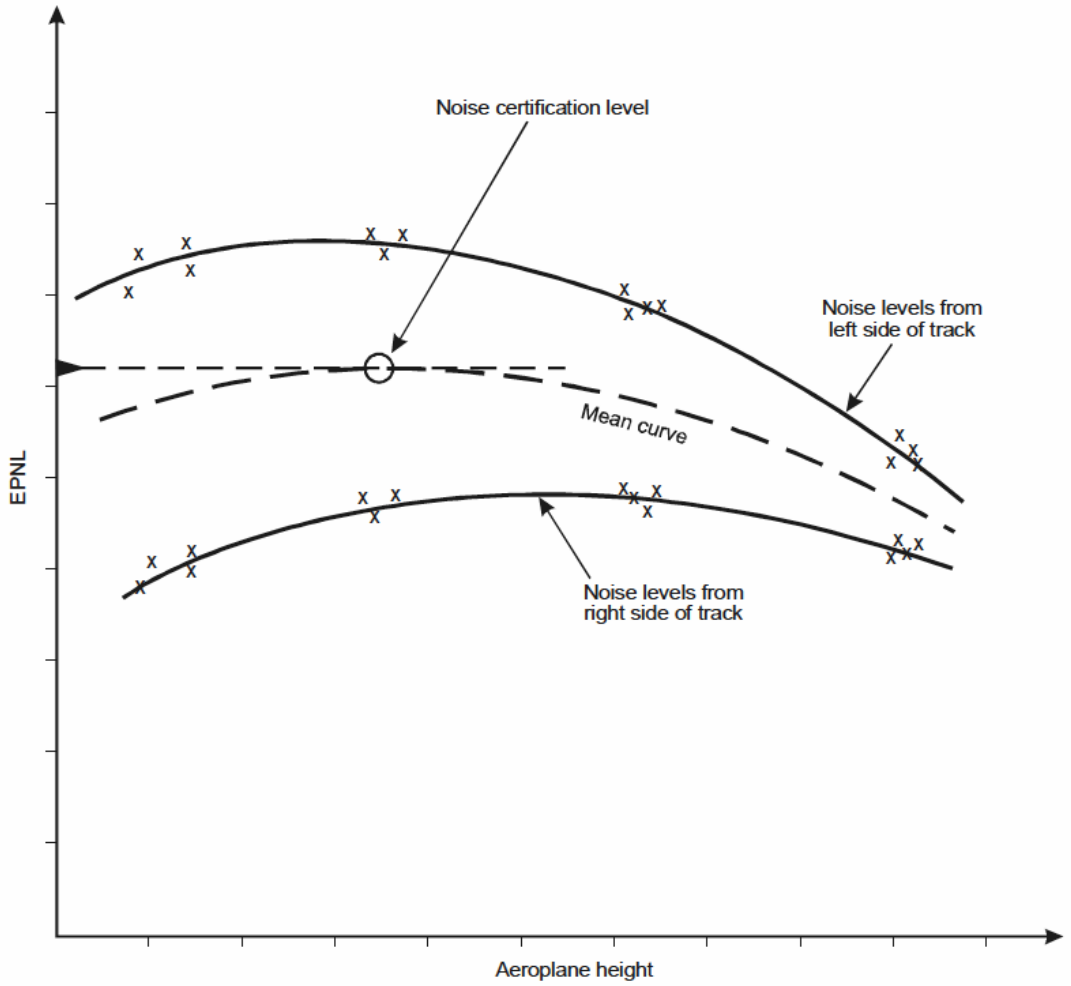


Figure 9. Typical lateral noise data plot for heavy propeller-driven aeroplanes

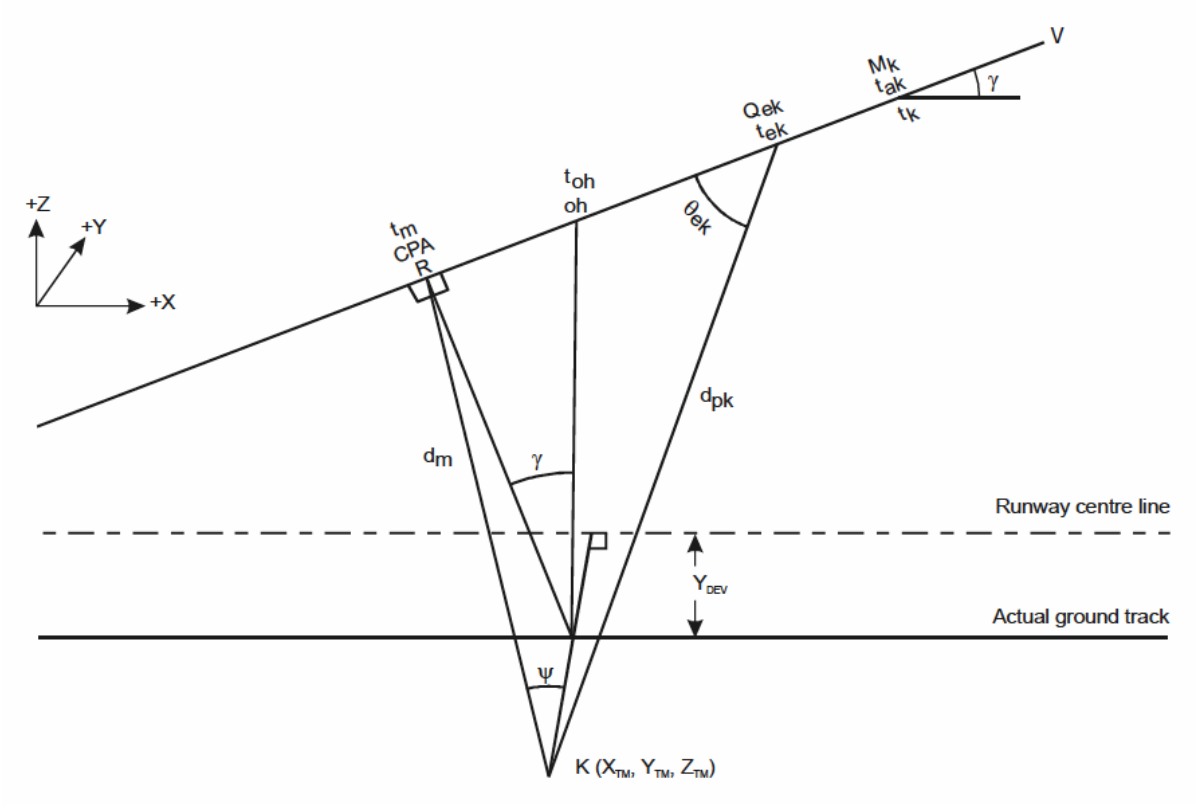


Figure 10. Geometry for integrated procedure

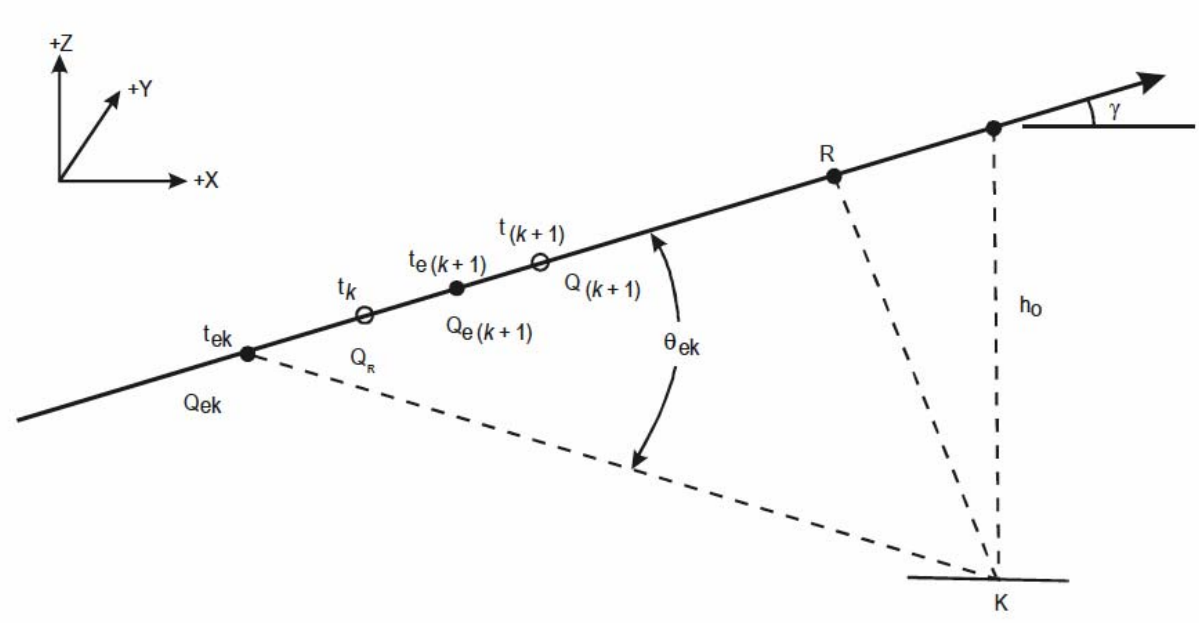


Figure 11. Relative time periods for integrated procedure

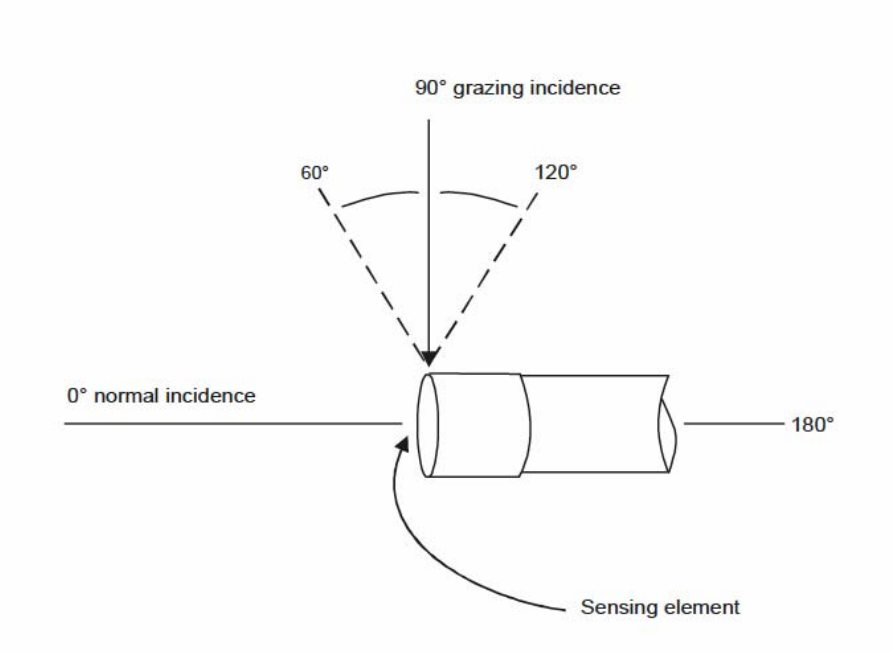


Figure 12. Illustration of sound incidence angles on a microphone

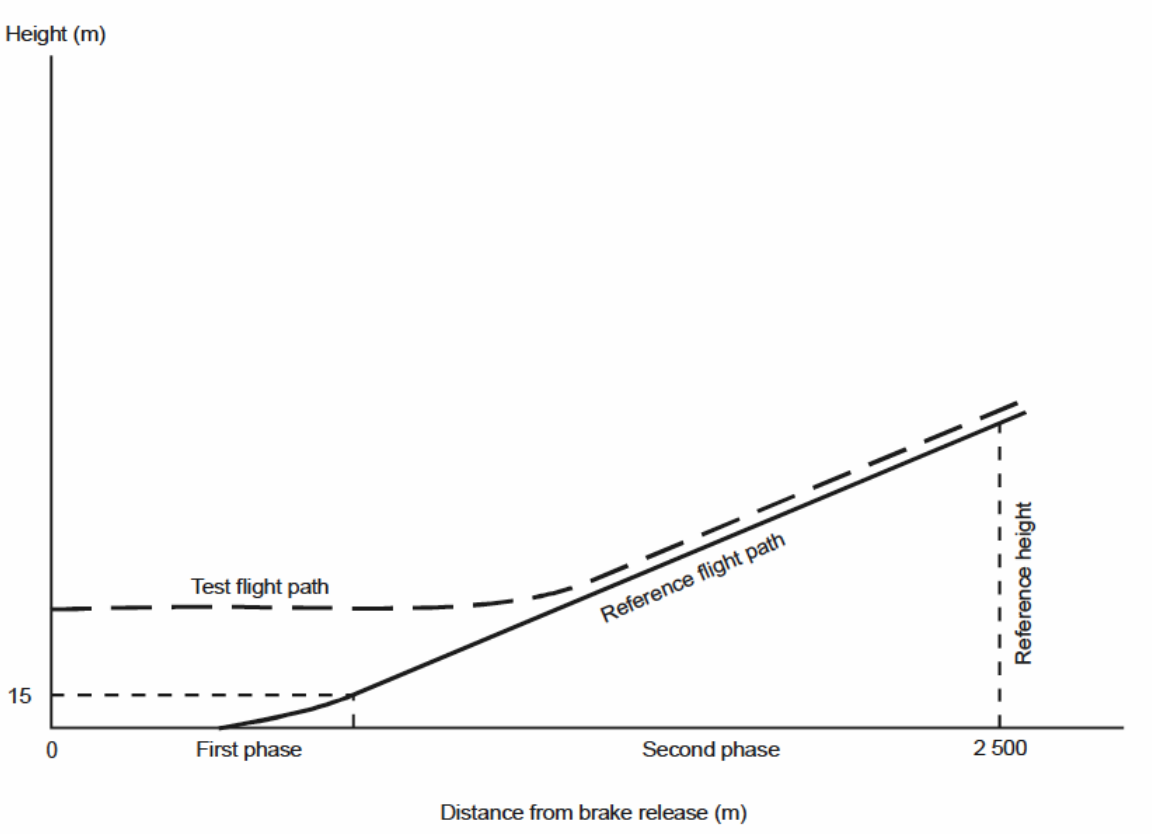


Figure 13. Typical test and reference procedures

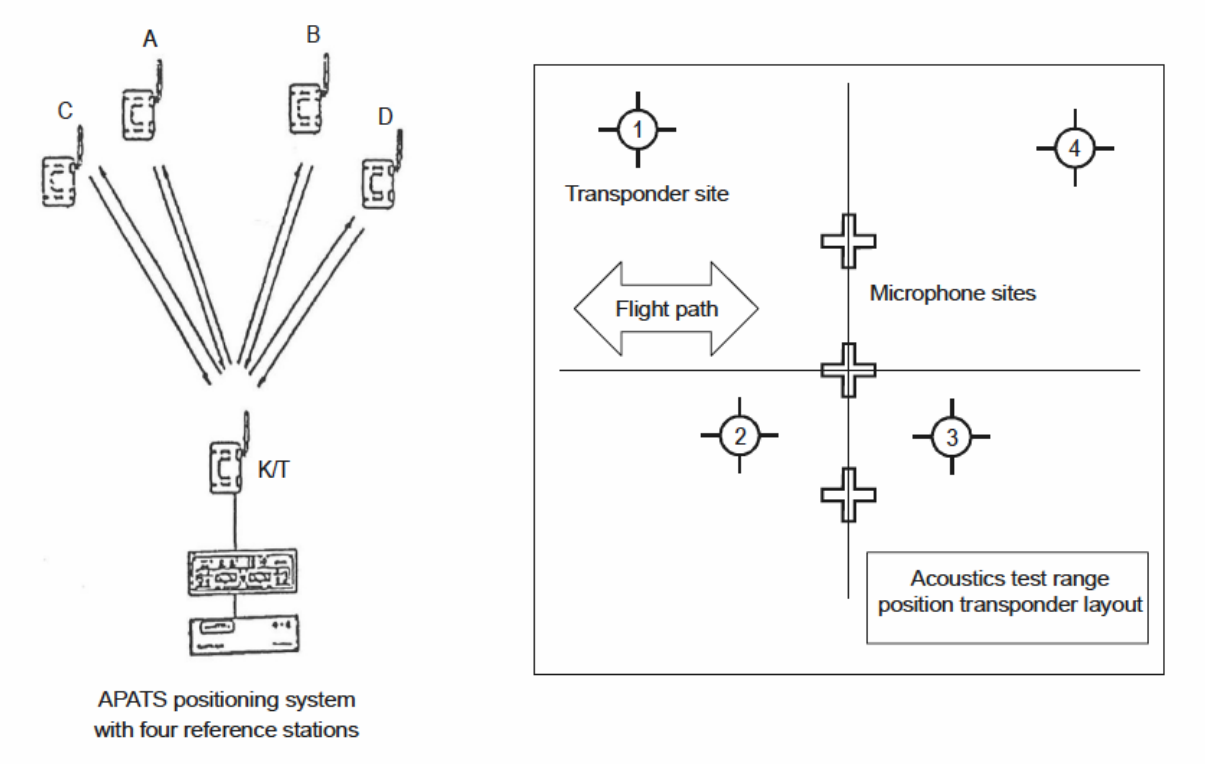


Figure 14. Radar position tracking system

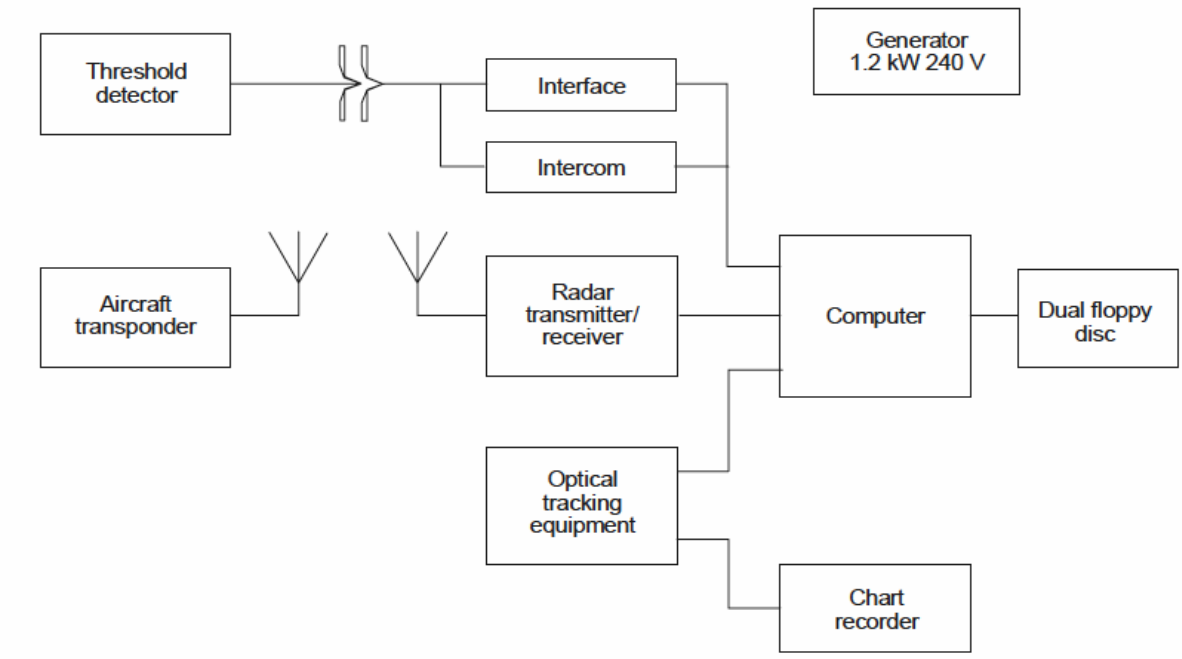


Figure 15. Radar/optical position tracking system

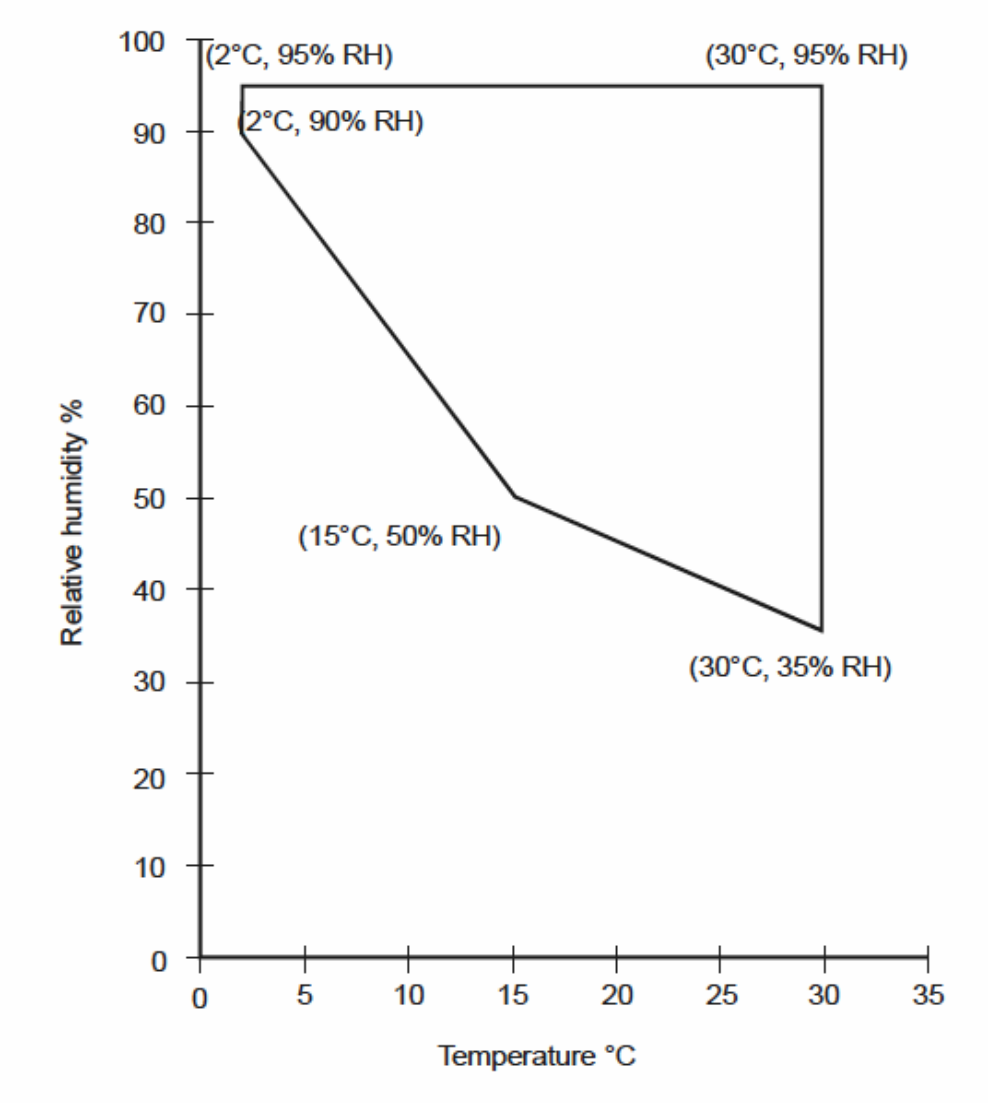


Figure 16. Annex 16 Chapter 8 zero attenuation adjustment window

Appendix 1 - CALCULATION OF CONFIDENCE INTERVALS

1. INTRODUCTION

The use of Noise-Power-Distance (NPD) curves requires that confidence intervals be determined using a more general formulation than is used for a cluster of data points. For this more general case confidence intervals may need to be calculated about a regression line for:

(a) flight test data,

(b) a combination of flight test and static test data,

(c) analytical results,

or a combination thereof.

The latter two are of particular significance for noise certifications of an aircraft model range and require special care when pooling the different sources of sampling variability.

Sections 2 to 5 provide an insight into the theory of confidence interval evaluation. The application of this theory and some worked examples are presented in Section 6. A suggested bibliography is given in Section 7 for those wishing to gain a greater understanding.

2. CONFIDENCE INTERVAL FOR THE MEAN OF FLIGHT TEST DATA

2.1 Confidence interval for the sample estimate of the mean of clustered measurements

If n measurements of effective perceived noise levels y_1, y_2, ... , y_n, are obtained under approximately the same conditions and it can be assumed that they constitute a random sample from a normal population with true population mean, μ , and true standard deviation, σ D_Dd_____Ãĝƨƨ_____ __

$\bar{y}$ = estimate of the mean = $\frac{1}{n}\left\{\sum_{i=1}^{n} y(i)\right\}$,

s = estimate of the standard deviation = $\sqrt{\frac{\sum_{i=1}^{n}(y_i - \bar{y})^2}{n-1}}$

From these and the Student's t-distribution, the confidence interval, CI , for the estimate of the mean, $\bar{y}$, can be determined, as:

t

where denotes the percentile of the single-sided Student's t-test

with ζ degrees of freedom (for a clustered data set $\zeta = n - 1$) and where α is defined such that percent is the desired confidence level for the confidence interval. That is, it denotes the probability with which the interval will contain the unknown mean, μ. For noise certification purposes 90% confidence intervals are generally desired and, thus $t_{0.95,\zeta}$ is used. See Table 1-2 situated at the end of this appendix for a listing of values of $t_{0.95,\zeta}$ for different values of ζ .

2.2 Confidence interval for mean Line obtained by regression

If n measurements of effective perceived noise levels y_1, y_2, ... , y_n are obtained under significantly varying values of engine-related parameter x_1, x_2, ... , x_n, respectively, then a polynomial can be fitted to the data by the method of least squares. The following polynomial regression model for the mean effective perceived noise level, μ, is assumed to apply:

$$\mu = B_0 + B_1 x + B_2 x^2 + \cdots + B_k x^k$$

and the estimate of the mean line through the data of the effective perceived noise level is given by:

$$y = b_0 + b_1 x + b_2 x^2 + \cdots + b_k x^k$$

Each regression coefficient B_i is estimated by b_i from the sample data using the method of least squares in a process summarised below.

Every observation (x_i, y_i) satisfies the equations

$$y_i = B_0 + B_1 x_i + B_2 x_i^2 + \cdots + B_k x_i^k + \varepsilon_i$$
$$= b_0 + b_1 x_i + b_2 x_i^2 + \cdots + b_k x_i^k + e_i$$

where ε_i and e_i are the random error and residual associated with the effective perceived noise level. The random error, ε_i, is assumed to be a random sample from a normal population with mean zero and standard deviation σ. The residual, e_i, is the difference between the measured value and the estimate of the value using the estimates of the regression coefficients and x_i. Its root mean square value, *s*, is the sample estimate for σ. These equations are often referred to as the normal equations.

The *n* data points of measurements (x_i,y_i) are processed as follows:

Each elemental vector, $\underline{x}_i$, and its transpose $\underline{x}_i'$, are formed such that

$\underline{x}_i = \begin{pmatrix} 1 & x_i & x_i^2 & \cdots & x_i^k \end{pmatrix}$, a row vector,

and $\underline{x}'_i = \begin{pmatrix} 1 \\ x_i \\ x_i^2 \\ \vdots \\ x_i^k \end{pmatrix}$, a column vector.

A matrix $\underline{X}$ is formed from all the elemental vectors $\underline{x}_i$ for i = 1,....,*n*. $\underline{X}'$ __D_Dd_____¥Ï$\underline{X}$.

We define a matrix $\underline{A}$ such that $\underline{A} = \underline{X}'\underline{X}$ and a matrix to be the inverse of $\underline{A}$.

Also $\underline{y} = \begin{pmatrix} y_1 & y_2 & \cdots & y_n \end{pmatrix}$,

and $\underline{b} = \begin{pmatrix} b_0 & b_1 & \cdots & b_k \end{pmatrix}$

with $\underline{b}$ determined as the solution of the normal equations:

$$\underline{y} = \underline{X}\underline{b}$$

and $\underline{X}'\underline{y} = \underline{X}'\underline{X}\,\underline{b} = \underline{A}\,\underline{b}$,

to give .

The 90% confidence interval, CI_{90}, for the mean value of the effective perceived noise level estimated with the associated value of the engine-related parameter, x_0, is then defined as

$$CI_{90} = \bar{y}(x_0) \pm t_{.95,\zeta} sv(x_0)$$

where $v(x_0) = \sqrt{\underline{x}_0 \underline{A}^{-1} \underline{x}'_0}$

Thus $CI_{90} = \bar{y}(x_0) \pm t_{.95,\zeta} s\sqrt{\underline{x}_0 \underline{A}^{-1} \underline{x}'_0}$

where $\underline{x}_0 = (1 \quad x_0 \quad x_0^2 \quad \cdots \quad x_0^k)$,

$\underline{x}'_0$ is the transpose of $\underline{x}_0$,

$\bar{y}(x_0)$ is the estimate of the mean value of the effective perceived noise level at the associated value of the engine related parameter,

$t_{.95,\zeta}$ is obtained for ζ degrees of freedom. For the general case of a multiple regression analysis involving K independent variables (i.e. K+1 coefficients) ζ is defined as $\zeta = n - K - 1$ (for the specific case of a polynomial regression analysis, for which k is the order of curve fit, we have k variables independent of the dependent variable, and so $\zeta = n - K - 1$),

and $s = \sqrt{\dfrac{\sum_{i=1}^{n} (y_i - \bar{y}(x_i))^2}{n - K - 1}}$, the estimate of σ [illegible]

3. CONFIDENCE INTERVAL FOR STATIC TEST DERIVED NPD CURVES

When static test data is used in family certifications, NPD curves are formed by the linear combination of baseline flight regressions, baseline projected static regressions, and derivative projected static regressions in the form:

or using the notation adopted above:

$$\bar{y}_{DF}(x_0) = \bar{y}_{BF}(x_0) - \bar{y}_{BS}(x_0) + \bar{y}_{DS}(x_0)$$

where subscript *DF* denotes derivative flight, *BF* denotes baseline flight, *BS* denotes baseline static, and *DS* denotes derivative static.

Confidence intervals for the derivative flight NPD curves are obtained by pooling the three data sets (each with their own polynomial regression). The

confidence interval for the mean derived effective perceived noise level at engine-related parameter x_0, i.e., for $\mu_{DF}(x_0)$, is given by:

$$CI_{90}(x_0) = \bar{y}_{DF}(x_0) \pm t' v_{DF}(x_0)$$

where $v_{DF}(x_0) = \sqrt{(s_{BF} v_{BF}(x_0))^2 + (s_{BS} v_{BS}(x_0))^2 + (s_{DF} v_{DF}(x_0))^2}$ with s_{BF}, s_{BS}, s_{DS}, $v_{BF}(x_0)$, $v_{BS}(x_0)$ and $v_{DS}(x_0)$ computed as explained in Section 2.2 for the respective data sets indicated by the subscripts *BF*, *BS*, and *DS*, and

$$t' = \frac{(s_{BF} v_{BF}(x_0))^2 t_{BF} + (s_{BS} v_{BS}(x_0))^2 t_{BS} + (s_{DS} v_{DS}(x_0))^2 t_{DS}}{(s_{BF} v_{BF}(x_0))^2 + (s_{BS} v_{BS}(x_0))^2 + (s_{DS} v_{DS}(x_0))^2}$$

where t_{BF}, t_{BS} and t_{DS} are the $t_{\beta,\xi}$ values each evaluated with the respective degrees of freedom ξ_{BF}, ξ_{BS} and ξ_{DS} as they arise in the corresponding regressions.

4. CONFIDENCE INTERVAL FOR ANALYTICALLY DERIVED NPD CURVES

Analysis may be used to determine the effect of changes in noise source components on certificated levels. This is accomplished by analytically determining the effect of hardware change on the noise component it generates. The resultant delta is applied to the original configuration and new noise levels are computed. The changes may occur on the baseline configuration or on subsequent derivative configurations. The confidence intervals for this case are computed using the appropriate method from above. If $\hat{\Delta}$ represents the analytically determined change and if it is assumed that it may deviate from the true unknown Δ by some random amount d, i.e.

$$\hat{\Delta} = \Delta + d$$

where d is assumed to be normally distributed with mean zero and known variance τ^2,

then the confidence interval for $\mu(x_0) + \Delta$ is given by

$$\left(\bar{y}(x_0) + \hat{\Delta}\right) \pm t' v'(x_0)$$

where $v'(x_0) = \sqrt{v(x_0)^2 + \tau^2}$ and τ^2 is as above without change.

5. ADEQUACY OF THE MODEL

5.1 Choice of engine-related parameter

Every effort should be made to determine the most appropriate engine-related parameter x, which may be a combination of various simpler parameters.

5.2 Choice of regression model

It is not recommended in any case that polynomials of greater complexity than a simple quadratic be used for certification purposes, unless there is a clear basis for such a model.

Standard texts on multiple regression should be consulted and the data available should be examined to show the adequacy of the model chosen.

6.WORKED EXAMPLE OF THE DETERMINATION OF 90% CONFIDENCE INTERVALS FROM THE POOLING OF THREE DATA SETS

This section presents an example of the derivation of the 90% confidence intervals arising from the pooling of three data sets. Worked examples and guidance material are presented for the calculation of confidence intervals for a clustered data set and for first order (ie. straight line) and second order (ie. quadratic) regression curves. In addition, it is shown how the confidence interval shall be established for the pooling together of several data sets.

Consider the theoretical evaluation of the certification noise levels for an aircraft retro-fitted with silenced engines. The approach noise level for the datum aircraft was derived from a clustered data set of noise levels measured at nominally reference conditions, to which were added source noise corrections derived from a quadratic least squares curve fit through a series of data points made at different engine thrusts. In order to evaluate the noise levels for the aircraft fitted with acoustically treated engines a further source noise curve (assumed to be a straight least squares regression line) was established from a series of measurements of the silenced aircraft. Each of the three data bases is assumed to be made up of data unique to each base.

The clustered data set consists of six EPNL levels for the nominal datum hardwall condition. These levels have been derived from measurements which

have been fully corrected to the hardwall approach reference condition.

The two curves which determine the acoustic changes are the regression curves (in the example given both a quadratic and straight line least squares curve fit) for the plots of EPNL against normalised thrust for the hardwall and silenced conditions. These are presented in figure below. The dotted lines plotted about each line represent the boundaries of 90% confidence.

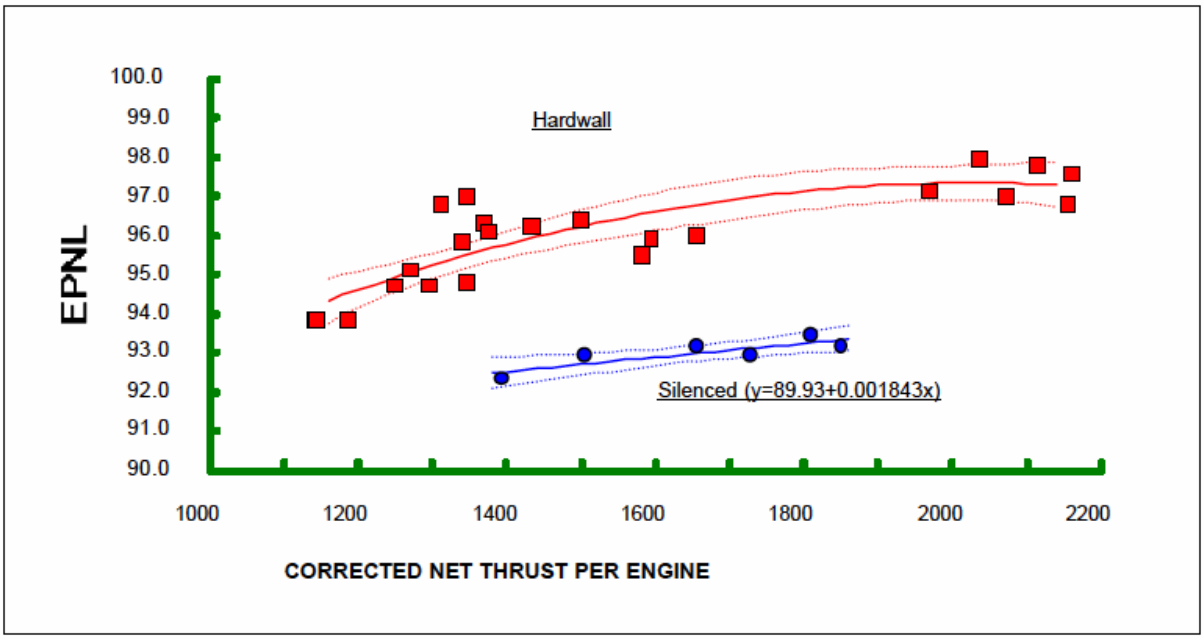


Figure 1.1

Each of the two curves is made up of from the full set of data points obtained for each condition during a series of back to back tests. The least squares fits therefore have associated with them all the uncertainties contained within each data set. It is considered that the number of data points in each of the three sets is large enough to constitute a statistical sample.

6.1 Confidence interval for a clustered data set

The confidence interval of the clustered data set is defined as follows:

Let $EPNL_i$ be the individual values of $EPNL$

n = number of data points

t = Student's t-distribution for (n-1) degrees of freedom (the number of degrees of freedom associated with a clustered data set).

Then the Confidence Interval $CI = \overline{EPNL} \pm t\frac{s}{\sqrt{n}}$

where s, the estimate of the standard deviation, is defined as

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(EPNL_i - \overline{EPNL}\right)^2}{n-1}}$$

and

$$\overline{EPNL} = \frac{\sum_{i=1}^{n} EPNL_i}{n}$$

Let us suppose that our clustered set of EPNL values consists of the following:

Run Number	EPNL
1	95.8
2	94.8
3	95.7
4	95.1
5	95.6
6	95.3

Then number of data points (n) = 6, degrees of freedom (n-1) = 5, Student's t-distribution for 5 degrees of freedom = 2.015 (See Table 1-2),

$$\overline{EPNL} = \frac{\sum_{i=1}^{n} EPNL_i}{n} = 95.38$$

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(EPNL_i - \overline{EPNL}\right)^2}{n-1}} = 0.3869$$

and Confidence Interval

$$CI = \overline{EPNL} \pm t\frac{s}{\sqrt{n}} = 95.38 \pm 2.015\frac{0.3869}{\sqrt{6}} = 95.38 \pm 0.1383$$

6.2 Confidence interval for a first order regression curve

Let us suppose that the regression curve for one of the source noise data sets (for the silenced case) can best be represented by a least squares straight line fit ie. a first order polynomial.

The equation for this regression line is of the general form:

$$Y = a + bX$$

where Y represents the dependent variable *EPNL*, and X represents the independent variable normalised thrust F_N/δ, (in this case).

Although for higher order polynomial least squares curves a regression line's coefficients (ie. the solutions to the "normal equations") are best established through computer matrix solutions, the two coefficients for a straight line fit, a and b, can be determined from the following two simple formulae for the measured values of X and Y, X_i and Y_i:

$$b = \frac{\textbf{Covariance}}{\textbf{Variance}} = \frac{S_{xy}^2}{S_x^2}$$

where $S_{xy}^2 = \dfrac{\sum_{i=1}^{n} X_i Y_i}{n} - \dfrac{\sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{n^2}$,

and $S_x^2 = \dfrac{\sum_{i=1}^{n} X_i^2}{n} - \left(\dfrac{\sum_{i=1}^{n} X_i}{n} \right)^2$,

$$a = \frac{\sum_{i=1}^{n} Y_i - b\sum_{i=1}^{n} X_i}{n}$$

The 90% confidence interval about this regression line for $X = x_0$ is then defined by:

$$CI_{90} = \overline{Y} \pm ts\sqrt{\underline{x_0}\,\underline{A}^{-1}\,\underline{x_0'}}$$

where t = Student's t-distribution for 90% confidence corresponding to (n - k - 1) degrees of freedom (where k is the order of the polynomial regression line

and n is the number of data points),

$\underline{x_0} = \begin{pmatrix} 1 & x_0 \end{pmatrix}$,

$\underline{x_0'} = \begin{pmatrix} 1 \\ x_0 \end{pmatrix}$

$\underline{A}^{-1}$ is the inverse of $\underline{A}$ where $\underline{A} = \underline{X}' \underline{X}$,

with $\underline{X}$ and $\underline{X'}$ defined as in paragraph 2.2 from the elemental vectors formed from the measured values of independent variable X_i,

$$s = \sqrt{\frac{\sum_{i=1}^{n} (\Delta Y)_i^2}{n-k-1}},$$

where $(\Delta Y)_i$ = the difference between the measured value of Y_i at its associated value of X_i, and the value of Y derived from the least squares fit straight line for $X = X_i$, and n and k are defined as above.

Let us suppose that our data set consists of the following set of six EPNL values together with their associated values of engine related parameter (Note that it would be usual to have more than six data points making up a source noise curve but in order to limit the size of the matrices in this example their number has been restricted):

Table 1-1

Run Number	F_N/δ	EPNL
1	1395	92.3
2	1505	92.9
3	1655	93.2
4	1730	92.9
5	1810	93.4
6	1850	93.2

By plotting this data (See Figure 1.1) it can be seen by examination that a linear relationship between EPNL (the dependent variable Y) and F_N/δ (the independent variable X) is suggested with the following general form:

$$Y = a + bX$$

The coefficients a and b of the linear equation are defined as above and may be calculated as follows:

X	Y	XY	X^2
1395	92.3	128759	1946025
1505	92.9	139815	2265025
1655	93.2	154246	2739025
1730	92.9	160717	2992900
1810	93.4	169054	3276100
1850	93.2	172420	3422500
$\sum X$	$\sum Y$	$\sum XY$	$\sum X^2$
9945	557.9	925010	16641575

$$b = \frac{\text{Covariance}}{\text{Variance}} = \frac{S_{xy}^2}{S_x^2}$$

where

$$S_{xy}^2 = \frac{\sum_{i=1}^{n} X_i Y_i}{n} - \frac{\sum_{i=1}^{n} X_i \sum_{i=1}^{n} Y_i}{n^2} = \frac{925010}{6} - \frac{9945 \times 557.9}{36} = 48.46$$

and

$$S_x^2 = \frac{\sum_{i=1}^{n} X_i^2}{n} - \left(\frac{\sum_{i=1}^{n} X_i}{n} \right)^2 = \frac{16641575}{6} - \left(\frac{9945}{6} \right)^2 = 26289.6$$

to give $b = \frac{48.46}{26289.6} = 0.001843$

and $a = \frac{\sum_{i=1}^{n} Y_i - b \sum_{i=1}^{n} X_i}{n} = \frac{557.9 - 0.001843 \times 9945}{6} = 89.93$

The 90% confidence interval about this regression line which is defined as:

$$CI_{90} = \overline{Y} \pm ts \sqrt{\underline{x}_0 \underline{A}^{-1} \underline{x}_0'}$$

is calculated as follows.

From the single set of measured independent variables tabulated in Table 1-1 let us form the matrix, $\underline{X}$, from the elemental row vectors such that:

$$\underline{X} = \begin{pmatrix} 1 & 1395 \\ 1 & 1505 \\ 1 & 1655 \\ 1 & 1730 \\ 1 & 1810 \\ 1 & 1850 \end{pmatrix}$$

and $\underline{X'}$, the transpose of $\underline{X}$, where

$$\underline{X'} = \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 \\ 1395 & 1505 & 1655 & 1730 & 1810 & 1850 \end{pmatrix}$$

Matrix $\underline{A} = \underline{X'}\underline{X} = \begin{pmatrix} 6 & 9945 \\ 9945 & 16641575 \end{pmatrix}$ and its inverse $\underline{A}^{-1} = \begin{pmatrix} 175836 & -0.01051 \\ -0.01051 & 6.3396\text{E}-6 \end{pmatrix}$

Note: The manipulation of matrices, their multiplication and inversion, are best performed by computers via standard routines. Such routines are possible using standard functions contained within many commonly used spreadsheets.

Suppose for example we now wish to find the 90% confidence interval about the regression line for a value of F_N/δ (i.e. x_0) of 1600. We form the row vector x_0 such that:

$\underline{x_0} = (1 \quad 1600)$ and its transpose, a column vector $\underline{x_0'} = \begin{pmatrix} 1 \\ 1600 \end{pmatrix}$

From our calculation of $\underline{A}^{-1}$ we have:

$$\underline{x_0}\underline{A^{-1}} = (1 \quad 1600)\begin{pmatrix} 17.5836 & -0.01051 \\ -0.01051 & 6.3396\text{E}-6 \end{pmatrix} = (0.7709 \quad -3.6453\text{E}-4)$$

$$\underline{x_0}\underline{A^{-1}}\underline{x_0'} = (0.7709 \quad -3.6453\text{E}-4)\begin{pmatrix} 1 \\ 1600 \end{pmatrix} = 0.1876$$

Our equation for confidence interval also requires that we evaluate the value of standard deviation for the measured data set. From Table 1-1 and our regression equation for the least squares best fit straight line (from which we calculate the predicted value of EPNL at each of the 6 measured values of F_N/δ

we proceed as follows:

Run Number	F_N/δ	EPNL(Measured)	EPNL(Predicted)	$(\Delta EPNL)^2$
1	1395	92.3	92.50	0.03979
2	1505	92.9	92.70	0.03911
3	1655	93.2	92.98	0.04896
4	1730	92.9	93.12	0.04708
5	1810	93.4	93.26	0.01838
6	1850	93.2	93.34	0.01909

For $n = 6$ and $k = 1$,

$$s = \sqrt{\frac{\sum_{i=1}^{n}(\Delta Y)_i^2}{n-k-1}} = \sqrt{\frac{0.21241}{6-1-1}} = 0.2304$$

and so taking the value of Student's t from Table 1-2 for (n - k - 1) degrees of freedom (i.e. 4) to be 2.132, we have the confidence interval about the regression line at F_N/δ =1600 defined as follows:

$$CI_{90} = \overline{EPNL} \pm ts\sqrt{\underline{x_0}\,\underline{A}^{-1}\,\underline{x_0'}} = 92.98 \pm 2.132 \times 0.2304\sqrt{0.1876} = 92.98 \pm 0.2128$$

In order to establish the lines of 90% confidence intervals about a regression line the values of CI_{90} for a range of values of independent variable(s) should be calculated, through which a line can be drawn. These lines are shown as the dotted lines on Figure 1.1.

6.3 Confidence interval for a second order regression curve

The confidence intervals about a second order regression curve are derived in a similar manner to those for a straight line detailed in Section 6.1. It is not felt that a detailed example of their calculation would be appropriate. However, the following points should be borne in mind.

The coefficients of the least squares regression quadratic line are best determined via computer matrix solutions. Regression analysis functions are a common feature of many proprietary software packages.

The matrices $\underline{x_0}$, $\underline{x_0'}$, $\underline{X}$ and $\underline{X'}$ formed during the computation of the

confidence interval according to the formula:

$$CI_{90} = \overline{Y} \pm ts\sqrt{\underline{x_0}\,\underline{A}^{-1}\,\underline{x_0'}}$$

are formed from 1 × 3 and 3 × 1 row and column vectors respectively, made up from the values of independent variable X according to the following general form:

$$\underline{x} = \begin{pmatrix} 1 & x & x^2 \end{pmatrix}, \quad \underline{x'} = \begin{pmatrix} 1 \\ x \\ x^2 \end{pmatrix}$$

The number of degrees of freedom associated with a multiple regression analysis involving K variables independent of the dependent variable (ie. with (K + 1) coefficients, including the constant term) is defined as (n - K - 1). For a second order regression curve we have two independent variables and so the number of degrees of freedom is (n - 3).

6.4 Confidence interval for the pooled data set

The confidence interval associated with the pooling of three data sets is defined as follows:

$$CI = \overline{Y} \pm T'\sqrt{\sum_{i=1}^{3} Z_i^2}$$

where $Z_i = \dfrac{CI_i}{t_i}$,

$$T_i = \frac{\sum_{i=1}^{3} Z_i^2 t_i}{\sum_{i=1}^{3} Z_i^2}$$

CI_i = confidence interval for the i'th data set and t_i = value of Student's t for the i'th data set.

The different stages in the calculation of the confidence interval at our reference thrust of F_N/δ =1600 for the pooling of our three data sets is summarised below:

Description	Function	Datum	Hardwall	Silenced
Reference Thrust	F_N/δ		1600	1600
90% Confidence Interval about the mean	CI_{90}	0.3183	0.4817	0.2128
Number of data points	n	6	23	6
Degree of curve fit	k	0	2	1
Number of independent variables	K	0	2	1
Number of degrees of freedom	$n-K-1$	5	20	4
Student's t	t	2.015	1.725	2.132
Z	CI_{90}/t	0.1580	0.2792	0.09981
Z^2	$(CI_{90}/t)^2$	2.4953E-2	7.7979E-2	9.9625E-3
Z^2t	$(CI_{90}/t)^2 t$	5.0280E-2	0.1345	2.1240E-2
$\sum Z^2$		0.1129		
$\sum(Z^2t)$		0.2060		
T	$\sum(Z^2t)/\sum Z^2$	1.8248		
$\sqrt{\sum Z^2}$		0.3360		
CI	$T\sqrt{\sum Z^2}$	0.6131		

7. BIBLIOGRAPHY

1. Hafner, New York, 1971. Kendal, M.G. and Stuart, A., The Advanced Theory of Statistics, Volumes 1 and 2, 3

2. Yule, G.U. and Kendall, M.G., An Introduction to the Theory of Statistics, 14th ed., Griffin, New York, 1950.

3. Walpole, R.E. and Myers R.H., Probability and Statistics for Engineers and Scientists. MacMillan, New York, 1972.

4. Cochran, W.G., Approximate Significance Levels of the Behrens-Fisher Test, Biometrics, 10 191-195, 1964.

5. Rose, D.M. and Scholz, F.W., Statistical Analysis of Cumulative Shipper-Receiver Data, NUREG/CR-2819, Division of Facility Operations, Office of Nuclear Regulatory Research, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555, NRC FIN B1076, 1983.

6. Snedecor, G.W. and Cochran, W.G., Statisitical Methods, 6th ed., The Iowa State University Press, Arnes, Iowa, 1968.

7. Wonnacott, T.H. and Wonnacott, R.J., Introductory Statistics, 5th ed., John Wiley & Sons, 1990

Table 1-2. Student's t-DISTRIBUTION (FOR 90% CONFIDENCE INTERVAL) FOR VARIOUS DEGREES OF FREEDOM

Degrees of Freedom (ζ)	$t_{.95,\zeta}$
1	6.314
2	2.920
3	2.353
4	2.132
5	2.015
6	1.943
7	1.895
8	1.860
9	1.833
10	1.812
12	1.782
14	1.761
16	1.746
18	1.734
20	1.725
24	1.711
30	1.697
60	1.671
>60	1.645

Values in the Student's t-distribution to give a probability of 0.95 that the population mean value, μ, is such that:

$$\mu \le \bar{y} + t_{.95,\zeta} \frac{s}{\sqrt{n}}$$

and thus a probability of 90% that

$$\bar{y} - t_{.95,\zeta} \frac{s}{\sqrt{n}} \le \mu \le \bar{y} + t_{.95,\zeta} \frac{s}{\sqrt{n}}$$

Appendix 2 - IDENTIFICATION OF SPECTRAL IRREGULARITIES

1.0 INTRODUCTION

Spectral irregularities which are not produced by aircraft noise sources may cause tone corrections to be generated when the procedures of Annex 16, Volume 1 paragraph 4.3 of Appendix 1 and 2, are used. These spectral irregularities may be caused by:

a) the reflected sound energy from the ground plane beneath the microphone mounted at 1.2 m above it, interfering with the direct sound energy from the aircraft. The re-enforcing and destructive effects of this interference is strongest at lower frequencies, typically 100 Hz to 200 Hz and diminishes with increasing frequency. The local peaks in the 1/3 octave spectra of such signals are termed pseudotones. Above 800 Hz this interference effect is usually insufficient to generate a tone correction when the Annex 16, Volume 1 tone correction procedures is used;

b) small perturbations in the propagation of aircraft noise when analysed with 1/3 octave bandwidth filters; or

c) the data processing adjustments and corrections such as the background noise correction method and the adjustment for atmospheric attenuation. In the case of the latter, the atmospheric attenuation coefficients (a) given in ARP866A ascribe a values at 4 kHz to the centre frequency of the 1/3 octave band whereas at 5 kHz the value of a is ascribed to the lower pass frequency of the 1/3 octave. This difference is sufficient in some cases to generate a tone correction.

The inclusion of a tone correction factor in the computation of EPNL accounts for the subjective response to the presence of pronounced spectral irregularities. Tones generated by aircraft noise sources are those for which the application of tone correction factors are appropriate. Tone correction factors which result from spectral irregularities, i.e. false tones produced by any of the above causes may be disregarded. This Appendix describes methods which have been approved for detecting and removing the effects of such spectral irregularities. However, approval of the use of any of these methods remains with the certificating authority.

2.0 METHODS FOR IDENTIFYING FALSE TONES

2.1 Frequency tracking

Frequency tracking of flyover noise data is useful for the frequency tracking of spectral irregularities. The observed frequency of aeroplane noise sources decrease continuously during the flyover due to Doppler frequency shift, f_{DOPP} where:

$$f_{DOPP} = \frac{f}{1 - M\cos\lambda}$$

where f is the frequency of the noise at source

M is the Mach number of the aeroplane

λ is the angle between the flight path in the direction of flight and a line connecting the source and observer at the time of emission.

Reflection related effects in the spectra, i.e. pseudotones, decrease in frequency prior to, and increase in frequency after, passing the closest point of aeroplane passing overhead, or the lateral point. Spectral irregularities caused by perturbations during the propagation of the noise from the aeroplane to the microphone tend to be random in nature in contrast to the Doppler effect. These differing characteristics can be used to separate source tones from false tones.

2.2 Narrow band analysis

Narrow band analysis with filter bandwidths narrower than those of 1/3 octaves is useful for identifying false tones. For example when the analysis is produced such that the spectral noise levels at an instance are presented in terms of image intensity on a line, the overall flyover analysis clearly indicates the Doppler shifted aeroplane tones and those due to reflection as described in paragraph 2.1.

2.3 Microphone mounting height

Comparison of 1/3 octave spectra of measurements taken using the 1.2 m high microphone and corresponding data obtained from a neighbouring microphone mounted flush on a hard reflecting surface, a configuration similar to that described in paragraph 4.4 of Appendix 6 of ICAO Annex 16, volume 1,

or at a height substantially greater than 1.2 m, such as 10 m, may be used to identify false tones. Changes to the microphone height alters the interference spectra irregularities from the frequency range of data from the 1.2 m high microphone and when a comparison is made between the two data sets collected at the same time, noise source tones can be separated from any false tones which may be present.

2.4 Inspection of noise time histories

Spectral irregularities which arise following data correction or adjustment (as described in (b) above) will occur in the frequency range of between 1 kHz to 10 kHz and the resulting false tone corrections will normally vary in magnitude between 0.2 to 0.6 dB. Time histories of perceived noise levels, PNL, and tone corrected perceived noise levels, PNLT, which exhibit constant level differences are often indicative of the presence of false tone corrections. Supplementary narrow band analysis is useful to demonstrate that such tone corrections are not due to aeroplane generated noise.

3.0 TREATMENT OF FALSE TONES

When spectral irregularities give rise to false tones which are identified by, for example, the methods described in Section 2 of this Appendix, their value, when computed in Step 9 of the tone correction calculation (described in Section 4.3 of Appendix 2 of Annex 16, Volume 1) may be set to zero.

Appendix 3 - A PROCEDURE FOR REMOVING THE EFFECTS OF AMBIENT NOISE LEVELS FROM AEROPLANE NOISE DATA

1.0 INTRODUCTION

1.1 The following information is provided as guidance material for certificating authorities on the method of removing the effect of ambient noise on aeroplane recorded noise.

1.2 This is not the only procedure which may be used and changes under certain instances may be made to it, but approval for its use in its current or modified form remains with the certificating authority.

2.0 Correction procedure

2.1 Aeroplane sound pressure levels within the 10 dB down points should exceed the mean ambient noise levels determined in section 7.5.6 of the manual by at least 3 dB in each one-third octave band or be corrected by the following or similar method.

1) The identification of the pre-detection and post-detection noise are made, i.e.:

a) one which adds to the recorded noise data on an energy basis, such as that from extraneous acoustic background noise signals or electrical noise from the microphone pre- amplifier and tape recorder is termed pre-detection noise; and

b) one which is non-additive but masks the aeroplane noise signal, such as would be produced by the presence of a lower level 'window' of the signal analyser, is termed postdetection noise.

2) Over the frequency range of the pre-detection noise, the background noise is subtracted from the analysed noise on an energy basis.

a) at frequencies of 630 Hz and below, if the analysed level is within 3 dB of the background pre-detection noise level ('masked' band), the corrected aeroplane noise is set equal to the pre-detection background level. If the analysed level is less than the background level, no changes are made to this level; and

b) at frequencies above 630 Hz, if the analysed level is within 3 dB or less than the predetection noise level, these levels are also identified as 'masked' and are corrected as in Steps 4), 5) and 6).

3) The remaining bands which fall inside the frequency range of the post-detection background noise are uncorrected unless they are within 3 dB of the identified post-detection noise, these bands are thus identified as 'masked' bands.

4) The 'as measured' spectrum is normalised to reference day conditions (25 C, 70% RH) and a distance from source of 60 m.

5) For the 'masked' high frequency bands at 60 m a linear extrapolation from the next lower frequency unmasked band of 0 dB/one-third octave, or a greater slope if derived from measured data, is applied.

6) The normalised spectrum is then converted back to 'as measured' distances and atmospheric conditions.

Note: If 'masked' pre- or post-detection bands are surrounded on both sides by 'unmasked' bands, no corrections are applied.

2.2 The following procedure is applicable to measured data where more than seven consecutive onethird octave bands are masked during a period of the noise time history.

Corrections by extrapolating in the time domain for frequencies above 630 Hz are made by taking into account propagation distance (spherical divergence and atmospheric attenuation) relative to the first (approaching) or last (receding) unmasked sound pressure level measurement in the one-third octave band requiring correction.

Source directional characteristics in each masked frequency band are assumed to be either:

a) directional, as supported by the applicant's test data or in the absence of such data; or

b) omnidirectional.

Appendix 4 - REFERENCE TABLES AND FIGURES USED IN THE MANUAL CALCULATION OF EFFECTIVE PERCEIVED NOISE LEVEL

This Appendix contains material useful in the manual calculation of Effective Perceived Noise Level. Such manual calculations are often required to verify the accuracy of computer programs used for calculating noise certification levels.

Table 4-1. Perceived noisiness (noys) as a function of sound pressure level

One-third octave band centre frequencies (Hz)

SPL	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
4																			0.10					
5																		0.10	0.11	0.10				
6																		0.11	0.12	0.11	0.10			
7																		0.12	0.14	0.13	0.11			
8																		0.14	0.16	0.14	0.13			
9																	0.10	0.16	0.17	0.16	0.14			
10																	0.11	0.17	0.19	0.18	0.16	0.10		
11																	0.13	0.19	0.22	0.21	0.18	0.12		
12																0.10	0.14	0.22	0.24	0.24	0.21	0.14		
13																0.11	0.16	0.24	0.27	0.27	0.24	0.16		
14																0.13	0.18	0.27	0.30	0.30	0.27	0.19		
15															0.10	0.14	0.21	0.30	0.33	0.33	0.30	0.22		
16										0.10	0.10	0.10	0.10	0.10	0.11	0.16	0.24	0.33	0.35	0.35	0.33	0.26		
17										0.11	0.11	0.11	0.11	0.11	0.13	0.18	0.27	0.35	0.38	0.38	0.35	0.30	0.10	
18									0.10	0.13	0.13	0.13	0.13	0.13	0.15	0.21	0.30	0.38	0.41	0.41	0.38	0.33	0.12	
19									0.11	0.14	0.14	0.14	0.14	0.14	0.17	0.24	0.33	0.41	0.45	0.45	0.41	0.36	0.14	
20									0.13	0.16	0.16	0.16	0.16	0.16	0.20	0.27	0.36	0.45	0.49	0.49	0.45	0.39	0.17	
21								0.10	0.14	0.18	0.18	0.18	0.18	0.18	0.23	0.30	0.39	0.49	0.53	0.53	0.49	0.42	0.21	0.10
22								0.11	0.16	0.21	0.21	0.21	0.21	0.21	0.26	0.33	0.42	0.53	0.57	0.57	0.53	0.46	0.25	0.11
23								0.13	0.18	0.24	0.24	0.24	0.24	0.24	0.30	0.36	0.46	0.57	0.62	0.62	0.57	0.50	0.30	0.13
24							0.10	0.14	0.21	0.27	0.27	0.27	0.27	0.27	0.33	0.40	0.50	0.62	0.67	0.67	0.62	0.55	0.33	0.15
25							0.11	0.16	0.24	0.30	0.30	0.30	0.30	0.30	0.35	0.43	0.55	0.67	0.73	0.73	0.67	0.60	0.36	0.17
26							0.13	0.18	0.27	0.33	0.33	0.33	0.33	0.33	0.38	0.48	0.60	0.73	0.79	0.79	0.73	0.65	0.39	0.20
27						0.10	0.14	0.21	0.30	0.35	0.35	0.35	0.35	0.35	0.41	0.52	0.65	0.79	0.85	0.85	0.79	0.71	0.42	0.23
28						0.11	0.16	0.24	0.33	0.38	0.38	0.38	0.38	0.38	0.45	0.57	0.71	0.85	0.92	0.92	0.85	0.77	0.46	0.26
29						0.13	0.18	0.27	0.35	0.41	0.41	0.41	0.41	0.41	0.49	0.63	0.77	0.92	1.00	1.00	0.92	0.84	0.50	0.30
30					0.10	0.14	0.21	0.30	0.38	0.45	0.45	0.45	0.45	0.45	0.53	0.69	0.84	1.00	1.07	1.07	1.00	0.92	0.55	0.33
31					0.11	0.16	0.24	0.33	0.41	0.49	0.49	0.49	0.49	0.49	0.57	0.76	0.93	1.07	1.15	1.15	1.07	1.00	0.60	0.37
32					0.13	0.18	0.27	0.36	0.45	0.53	0.53	0.53	0.53	0.53	0.62	0.83	1.00	1.15	1.23	1.23	1.15	1.07	0.65	0.41
33					0.14	0.21	0.30	0.39	0.49	0.57	0.57	0.57	0.57	0.57	0.67	0.91	1.07	1.23	1.32	1.32	1.23	1.15	0.71	0.45
34				0.10	0.16	0.24	0.33	0.42	0.53	0.62	0.62	0.62	0.62	0.62	0.73	1.00	1.15	1.32	1.41	1.41	1.32	1.23	0.77	0.50
35				0.11	0.18	0.27	0.36	0.46	0.57	0.67	0.67	0.67	0.67	0.67	0.79	1.07	1.23	1.41	1.51	1.51	1.41	1.32	0.84	0.55
36				0.13	0.21	0.30	0.40	0.50	0.62	0.73	0.73	0.73	0.73	0.73	0.85	1.15	1.32	1.51	1.62	1.62	1.51	1.41	0.92	0.61
37				0.15	0.24	0.33	0.43	0.55	0.67	0.79	0.79	0.79	0.79	0.79	0.92	1.23	1.41	1.62	1.74	1.74	1.62	1.51	1.00	0.67
38				0.17	0.27	0.37	0.48	0.60	0.73	0.85	0.85	0.85	0.85	0.85	1.00	1.32	1.51	1.74	1.86	1.86	1.74	1.62	1.10	0.74
39			0.10	0.20	0.30	0.41	0.52	0.65	0.79	0.92	0.92	0.92	0.92	0.92	1.07	1.41	1.62	1.86	1.99	1.99	1.86	1.74	1.21	0.82
40			0.12	0.23	0.33	0.45	0.57	0.71	0.85	1.00	1.00	1.00	1.00	1.00	1.15	1.51	1.74	1.99	2.14	2.14	1.99	1.86	1.34	0.90
41			0.14	0.26	0.37	0.50	0.63	0.77	0.92	1.07	1.07	1.07	1.07	1.07	1.23	1.62	1.86	2.14	2.29	2.29	2.14	1.99	1.48	1.00
42			0.16	0.30	0.41	0.55	0.69	0.84	1.00	1.15	1.15	1.15	1.15	1.15	1.32	1.74	1.99	2.29	2.45	2.45	2.29	2.14	1.63	1.10
43			0.19	0.33	0.45	0.61	0.76	0.92	1.07	1.23	1.23	1.23	1.23	1.23	1.41	1.86	2.14	2.45	2.63	2.63	2.45	2.29	1.79	1.21
44		0.10	0.22	0.37	0.50	0.67	0.83	1.00	1.15	1.32	1.32	1.32	1.32	1.32	1.52	1.99	2.29	2.63	2.81	2.81	2.63	2.45	1.99	1.34
45		0.12	0.26	0.42	0.55	0.74	0.91	1.08	1.24	1.41	1.41	1.41	1.41	1.41	1.62	2.14	2.45	2.81	3.02	3.02	2.81	2.63	2.14	1.48
46		0.14	0.30	0.46	0.61	0.82	1.00	1.16	1.33	1.52	1.52	1.52	1.52	1.52	1.74	2.29	2.63	3.02	3.23	3.23	3.02	2.81	2.29	1.63
47		0.16	0.34	0.52	0.67	0.90	1.08	1.25	1.42	1.62	1.62	1.62	1.62	1.62	1.87	2.45	2.81	3.23	3.46	3.46	3.23	3.02	2.45	1.79
48		0.19	0.38	0.58	0.74	1.00	1.17	1.34	1.53	1.74	1.74	1.74	1.74	1.74	2.00	2.63	3.02	3.46	3.71	3.71	3.46	3.23	2.63	1.98
49	0.10	0.22	0.43	0.65	0.82	1.08	1.26	1.45	1.64	1.87	1.87	1.87	1.87	1.87	2.14	2.81	3.23	3.71	3.97	3.97	3.71	3.46	2.81	2.18
50	0.12	0.26	0.49	0.72	0.90	1.17	1.36	1.56	1.76	2.00	2.00	2.00	2.00	2.00	2.30	3.02	3.46	3.97	4.26	4.26	3.97	3.71	3.02	2.40
51	0.14	0.30	0.55	0.80	1.00	1.26	1.47	1.68	1.89	2.14	2.14	2.14	2.14	2.14	2.46	3.23	3.71	4.26	4.56	4.56	4.26	3.97	3.23	2.63
52	0.17	0.34	0.62	0.90	1.08	1.36	1.58	1.80	2.03	2.30	2.30	2.30	2.30	2.30	2.64	3.46	3.97	4.56	4.89	4.89	4.56	4.26	3.46	2.81
53	0.21	0.39	0.70	1.00	1.18	1.47	1.71	1.94	2.17	2.46	2.46	2.46	2.46	2.46	2.83	3.71	4.26	4.89	5.24	5.24	4.89	4.56	3.71	3.02
54	0.25	0.45	0.79	1.09	1.28	1.58	1.85	2.09	2.33	2.64	2.64	2.64	2.64	2.64	3.03	3.97	4.56	5.24	5.61	5.61	5.24	4.89	3.97	3.23
55	0.30	0.51	0.89	1.15	1.35	1.71	2.00	2.25	2.50	2.83	2.83	2.83	2.83	2.83	3.25	4.26	4.89	5.61	6.01	6.01	5.61	5.24	4.26	3.46
56	0.34	0.59	1.00	1.29	1.50	1.85	2.15	2.42	2.69	3.03	3.03	3.03	3.03	3.03	3.48	4.56	5.24	6.01	6.44	6.44	6.01	5.61	4.56	3.71
57	0.39	0.67	1.09	1.40	1.63	2.00	2.33	2.61	2.88	3.25	3.25	3.25	3.25	3.25	3.73	4.89	5.61	6.44	6.90	6.90	6.44	6.01	4.89	3.97
58	0.45	0.77	1.18	1.53	1.77	2.15	2.51	2.81	3.10	3.48	3.48	3.48	3.48	3.48	4.00	5.24	6.01	6.90	7.39	7.39	6.90	6.44	5.24	4.26
59	0.51	0.87	1.29	1.66	1.92	2.33	2.71	3.03	3.32	3.73	3.73	3.73	3.73	3.73	4.29	5.61	6.44	7.39	7.92	7.92	7.39	6.90	5.61	4.56

One-third octave band centre frequencies (Hz)

SPL	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
60	0.59	1.00	1.40	1.81	2.08	2.51	2.93	3.26	3.57	4.00	4.00	4.00	4.00	4.00	4.59	6.01	6.90	7.92	8.49	8.49	7.92	7.39	6.01	4.89
61	0.67	1.10	1.53	1.97	2.26	2.71	3.16	3.51	3.83	4.29	4.29	4.29	4.29	4.29	4.92	6.44	7.39	8.49	9.09	9.09	8.49	7.92	6.44	5.24
62	0.77	1.21	1.66	2.15	2.45	2.93	3.41	3.78	4.11	4.59	4.59	4.59	4.59	4.59	5.28	6.90	7.92	9.09	9.74	9.74	9.09	8.49	6.90	5.61
63	0.87	1.32	1.81	2.34	2.65	3.16	3.69	4.06	4.41	4.92	4.92	4.92	4.92	4.92	5.66	7.39	8.49	9.74	10.4	10.4	9.74	9.09	7.39	6.01
64	1.00	1.45	1.97	2.54	2.88	3.41	3.98	4.38	4.73	5.28	5.28	5.28	5.28	5.28	6.06	7.92	9.09	10.4	11.2	11.2	10.4	9.74	7.92	6.44
65	1.11	1.60	2.15	2.77	3.12	3.69	4.30	4.71	5.08	5.66	5.66	5.66	5.66	5.66	6.50	8.49	9.74	11.2	12.0	12.0	11.2	10.4	8.49	6.90
66	1.22	1.75	2.34	3.01	3.39	3.98	4.64	5.07	5.45	6.06	6.06	6.06	6.06	6.06	6.96	9.09	10.4	12.0	12.8	12.8	12.0	11.2	9.09	7.39
67	1.35	1.92	2.54	3.28	3.68	4.30	5.01	5.46	5.85	6.50	6.50	6.50	6.50	6.50	7.46	9.74	11.2	12.8	13.8	13.8	12.8	12.0	9.74	7.92
68	1.49	2.11	2.77	3.57	3.99	4.64	5.41	5.88	6.27	6.96	6.96	6.96	6.96	6.96	8.00	10.4	12.0	13.8	14.7	14.7	13.8	12.8	10.4	8.49
69	1.65	2.32	3.01	3.88	4.33	5.01	5.84	6.33	6.73	7.46	7.46	7.46	7.46	7.46	8.57	11.2	12.8	14.7	15.8	15.8	14.7	13.8	11.2	9.09
70	1.82	2.55	3.28	4.23	4.69	5.41	6.31	6.81	7.23	8.00	8.00	8.00	8.00	8.00	9.19	12.0	13.8	15.8	16.9	16.9	15.8	14.7	12.0	9.74
71	2.02	2.79	3.57	4.60	5.09	5.84	6.81	7.33	7.75	8.57	8.57	8.57	8.57	8.57	9.85	12.8	14.7	16.9	18.1	18.1	16.9	15.8	12.8	10.4
72	2.23	3.07	3.88	5.01	5.52	6,31	7.36	7.90	8.32	9.19	9.19	9.19	9.19	9.19	10.6	13.8	15.8	18.1	19.4	19.4	18.1	16.9	13.8	11.2
73	2.46	3.37	4.23	5.45	5.99	6.81	7.94	8.50	8.93	9.85	9.85	9.85	9.85	9.85	11.3	14.7	16.9	19.4	20.8	20.8	19.4	18.1	14.7	12.0
74	2.72	3.70	4.60	5.94	6.50	7.36	8.57	9.15	9.59	10.6	10.6	10.6	10.6	10.6	12.1	15.8	18.1	20.8	22.3	22.3	20.8	19.4	15.8	12.8
75	3.01	4.06	5.01	6.46	7.05	7.94	9.19	9.85	10.3	11.3	11.3	11.3	11.3	11.3	13.0	16.9	19.4	22.3	23.9	23.9	22.3	20.8	16.9	13.8
76	3.32	4.46	5.45	7.03	7.65	8.57	9.85	10.6	11.0	12.1	12.1	12.1	12.1	12.1	13.9	18.1	20.8	23.9	25.6	25.6	23.9	22.3	18.1	14.7
77	3.67	4.89	5.94	7.66	8.29	9.19	10.6	11.3	11.8	13.0	13.0	13.0	13.0	13.0	14.9	19.4	22.3	25.6	27.4	27.4	25.6	23.9	19.4	15.8
78	4.06	5.37	6.46	8.33	9.00	9.85	11.3	12.1	12.7	13.9	13.9	13.9	13.9	13.9	16.0	20.8	23.9	27.4	29.4	29.4	27.4	25.6	20.8	16.9
79	4.49	5.90	7.03	9.07	9.76	10.6	12.1	13.0	13.6	14.9	14.9	14.9	14.9	14.9	17.1	22.3	25.6	29.4	31.5	31.5	29.4	27.4	22.3	18.1
80	4.96	6.48	7.66	9.85	10.6	11.3	13.0	13.9	14.6	16.0	16.0	16.0	16.0	16.0	18.4	23.9	27.4	31.5	33.7	33.7	31.5	29.4	23.9	19.4
81	5.48	7.11	8.33	10.6	11.3	12.1	13.9	14.9	15.7	17.1	17.1	17.1	17.1	17.1	19.7	25.6	29.4	33.7	36.1	36.1	33.7	31.5	25.6	20.8
82	6.06	7.81	9.07	11.3	12.1	13.0	14.9	16.0	16.9	18.4	18.4	18.4	18.4	18.4	21.1	27.4	31.5	36.1	38.7	38.7	36.1	33.7	27.4	22.3
83	6.70	8.57	9.87	12.1	13.0	13.9	16.0	17.1	18.1	19.7	19.7	19.7	19.7	19.7	22.6	29.4	33.7	38.7	41.5	41.5	38.7	36.1	29.4	23.9
84	7.41	9.41	10.7	13.0	13.9	14.9	17.1	18.4	19.4	21.1	21.1	21.1	21.1	21.1	24.3	31.5	36.1	41.5	44.4	44.4	41.5	38.7	31.5	25.6
85	8.19	10.3	11.7	13.9	14.9	16.0	18.4	19.7	20.8	22.6	22.6	22.6	22.6	22.6	26.0	33.7	38.7	44.4	47.6	47.6	44.4	41.5	33.7	27.4
86	9.95	11.3	12.7	14.9	16.0	17.1	19.7	21.1	22.4	24.3	24.3	24.3	24.3	24.3	27.9	36.1	41.5	47.6	51.0	51.0	47.6	44.4	36.1	29.4
87	10.0	12.1	13.9	16.0	17.1	18.4	21.1	22.6	24.0	26.0	26.0	26.0	26.0	26.0	29.0	38.7	44.4	51.0	54.7	54.7	51.0	47.6	38.7	31.5
88	11.1	13.0	14.9	17.1	18.4	19.7	22.6	24.3	25.8	27.9	27.9	27.9	27.9	27.9	32.0	41.5	47.6	54.7	58.6	58.6	54.7	51.0	41.5	33.7
89	12.2	13.9	16.0	18.4	19.7	21.1	24.3	26.0	27.7	29.9	29.9	29.9	29.9	29.9	34.3	44.4	51.0	58.6	62.7	62.7	58.6	54.7	44.4	36.1
90	13.5	14.9	17.1	19.7	21.1	22.6	26.0	27.9	29.7	32.0	32.0	32.0	32.0	32.0	36.8	47.6	54.7	62.7	67.2	67.2	62.7	58.6	47.6	38.7
91	14.9	16.0	18.4	21.1	22.6	24.3	27.9	29.9	31.8	34.3	34.3	34.3	34.3	34.3	39.4	51.0	58.6	67.2	72.0	72.0	67.2	62.7	51.0	41.5
92	16.0	17.1	19.7	22.6	24.3	26.0	29.9	32.0	34.2	36.8	36.8	36.8	36.8	36.8	42.2	54.7	62.7	72.0	77.2	77.2	72.0	67.2	54.7	44.4
93	17.1	18.4	21.1	24.3	26.0	27.9	32.0	34.3	36.7	39.4	39.4	39.4	39.4	39.4	45.3	58.6	67.2	77.2	82.7	82.7	77.2	72.0	58.6	47.6
94	18.4	19.7	22.6	26.0	27.9	29.9	34.3	36.8	39.4	42.2	42.2	42.2	42.2	42.2	48.5	62.7	72.0	82.7	88.6	88.6	82.7	77.2	62.7	51.0
95	19.7	21.1	24.3	27.9	29.9	32.0	36.8	39.4	42.2	45.3	45.3	45.3	45.3	45.3	52.0	67.2	77.2	88.6	94.9	94.9	88.6	82.7	67.2	54.7
96	21.1	22.6	26.0	29.9	32.0	34.3	39.4	42.2	45.3	48.5	48.5	48.5	48.5	48.5	55.7	72.0	82.7	94.9	102	102	94.9	88.6	72.0	58.6
97	22.6	24.3	27.9	32.0	34.3	36.8	42.2	45.3	48.5	52.0	52.0	52.0	52.0	52.0	59.7	77.2	88.6	102	109	109	102	94.9	77.2	62.7
98	24.3	26.0	29.9	34.3	36.8	39.4	45.3	48.5	52.0	55.7	55.7	55.7	55.7	55.7	64.0	82.7	94.9	109	117	117	109	102	82.7	67.2
99	26.0	27.9	32.0	36.8	39.4	42.2	48.5	52.0	55.7	59.7	59.7	59.7	59.7	59.7	68.6	88.6	102	117	125	125	117	109	88.6	72.0
100	27.9	29.9	34.3	39.4	42.2	45.3	52.0	55.7	59.7	64.0	64.0	64.0	64.0	64.0	73.5	94.9	109	125	134	134	125	117	94.9	77.2
101	29.9	32.0	36.8	42.2	45.3	48.5	55.7	59.7	64.0	68.6	68.6	68.6	68.6	68.6	78.8	102	117	134	144	144	134	125	102	82.7
102	32.0	34.3	39.4	45.3	48.5	52.0	59.7	64.0	68.6	73.5	73.5	73.5	73.5	73.5	84.4	109	125	144	154	154	144	134	109	88.6
103	34.3	36.8	42.2	48.5	52.0	55.7	64.0	68.6	73.5	78.8	78.8	78.8	78.8	78.8	90.5	117	134	154	165	165	154	144	117	94.9
104	36.8	39.4	45.3	52.0	55.7	59.7	68.6	73.5	78.8	84.4	84.4	84.4	84.4	84.4	97.0	125	144	165	177	177	165	154	125	102
105	39.4	42.2	48.5	55.7	59.7	64.0	73.5	78.8	84.4	90.5	90.5	90.5	90.5	90.5	104	134	154	177	189	189	177	165	134	109
106	42.2	45.3	52.0	59.7	64.0	68.6	78.8	84.4	90.5	97.0	97.0	97.0	97.0	97.0	111	144	165	189	203	203	189	177	144	117
107	45.3	48.5	55.7	64.0	68.6	73.5	84.4	90.5	97.0	104	104	104	104	104	119	154	177	203	217	217	203	189	154	125
108	48.5	52.0	59.7	68.6	73.5	78.8	90.5	97.0	104	111	111	111	111	111	128	165	189	217	233	233	217	203	165	134
109	52.0	55.7	64.0	73.5	78.8	84.4	97.0	104	111	119	119	119	119	119	137	177	203	233	249	249	233	217	177	144
110	55.7	59.7	68.6	78.8	84.4	90.5	104	111	119	128	128	128	128	128	147	189	217	249	267	267	249	233	189	154
111	59.7	64.0	73.5	84.4	90.5	97.0	111	119	128	137	137	137	137	137	158	203	233	267	286	286	267	249	203	165
112	64.0	68.6	78.8	90.5	97.0	104	119	128	137	147	147	147	147	147	169	217	249	286	307	307	286	267	217	177
113	68.6	73.5	84.4	97.0	104	111	128	137	147	158	158	158	158	158	181	233	267	307	329	329	307	286	233	189
114	73.5	78.8	90.5	104	111	119	137	147	158	169	169	169	169	169	194	249	286	329	352	352	329	307	249	203
115	78.8	84.4	97.0	111	119	128	147	158	169	181	181	181	181	181	208	267	307	352	377	377	352	329	267	217
116	84.4	90.5	104	119	128	137	158	169	181	194	194	194	194	194	223	286	329	377	404	404	377	352	286	233
117	90.5	97.0	111	128	137	147	169	181	194	208	208	208	208	208	239	307	352	404	433	433	404	377	307	249
118	97.0	104	119	137	147	158	181	194	208	223	223	223	223	223	256	329	377	433	464	464	433	404	329	267
119	104	111	128	147	158	169	194	208	223	239	239	239	239	239	274	352	404	464	497	497	464	433	352	286

One-third octave band centre frequencies (Hz)

SPL	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000	6300	8000	10000
120	111	119	137	158	169	181	208	223	239	256	256	256	256	256	294	377	433	497	533	533	497	464	377	307
121	119	128	147	169	181	194	223	239	256	274	274	274	274	274	315	404	464	533	571	571	533	497	404	329
122	128	137	158	181	194	208	239	256	274	294	294	294	294	294	338	433	497	571	611	611	571	533	433	352
123	137	147	169	194	208	223	256	274	294	315	315	315	315	315	362	464	533	611	655	655	611	571	464	377
124	147	158	181	208	223	239	274	294	315	338	338	338	338	338	388	497	571	655	702	702	655	611	497	404
125	158	169	194	223	239	256	294	315	338	362	362	362	362	362	416	533	611	702	752	752	702	655	533	433
126	169	181	208	239	256	274	315	338	362	388	388	388	388	388	446	571	655	752	806	806	752	702	571	464
127	181	194	223	256	274	294	338	362	388	416	416	416	416	416	478	611	702	806	863	863	806	752	611	497
128	194	208	239	274	294	315	362	388	416	446	446	446	446	446	512	655	752	863	925	925	863	806	655	533
129	208	223	256	294	315	338	388	416	446	478	478	478	478	478	549	702	806	925	991	991	925	863	702	571
130	223	239	274	315	338	362	416	446	478	512	512	512	512	512	588	752	863	991	1062	1062	991	925	752	611
131	239	256	294	338	362	388	446	478	512	549	549	549	549	549	630	806	925	1062	1137	1137	1062	991	806	655
132	256	274	315	362	388	416	478	512	549	588	588	588	588	588	676	863	991	1137	1219	1219	1137	1062	863	702
133	274	294	338	388	416	446	512	549	588	630	630	630	630	630	724	925	1062	1219	1306	1306	1219	1137	925	752
134	294	315	362	416	446	478	549	588	630	676	676	676	676	676	776	991	1137	1306	1399	1399	1306	1219	991	806
135	315	338	388	446	478	512	588	630	676	724	724	724	724	724	832	1062	1219	1399	1499	1499	1399	1306	1062	863
136	338	362	416	478	512	549	630	676	724	776	776	776	776	776	891	1137	1306	1499	1606	1606	1499	1399	1137	925
137	362	388	446	512	549	588	676	724	776	832	832	832	832	832	955	1219	1399	1606	1721	1721	1606	1499	1219	991
138	388	416	478	549	588	630	724	776	832	891	891	891	891	891	1024	1306	1499	1721	1844	1844	1721	1606	1306	1062
139	416	446	512	588	630	676	776	832	891	955	955	955	955	955	1098	1399	1606	1844	1975	1975	1844	1721	1399	1137
140	446	478	549	630	676	724	832	891	955	1024	1024	1024	1024	1024	1176	1499	1721	1975			1975	1844	1499	1219
141	478	512	588	676	724	776	891	955	1024	1098	1098	1098	1098	1098	1261	1606	1844					1975	1606	1306
142	512	549	630	724	776	832	955	1024	1098	1176	1176	1176	1176	1176	1351	1721	1975						1721	1399
143	549	588	676	776	832	891	1024	1098	1176	1261	1261	1261	1261	1261	1448	1844							1844	1499
144	588	630	724	832	891	955	1098	1176	1261	1351	1351	1351	1351	1351	1552	1975							1975	1606
145	630	676	776	891	955	1024	1176	1261	1351	1448	1448	1448	1448	1448	1664									1721
146	676	724	832	955	1024	1098	1261	1351	1448	1552	1552	1552	1552	1552	1783									1844
147	724	776	891	1024	1098	1176	1351	1448	1552	1664	1664	1664	1664	1664	1911									1975
148	776	832	955	1098	1176	1261	1448	1552	1664	1783	1783	1783	1783	1783	2048									
149	832	891	1024	1176	1261	1351	1552	1664	1783	1911	1911	1911	1911	1911										
150	891	955	1098	1261	1351	1448	1664	1783	1911	2048	2048	2048	2048	2048										

Table 4-2. Example of tone correction calculation for a turbofan engine

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Band (*i*)	*f* Hz	SPL dB	S dB Step 1	|ΔS| dB Step 2	SPL′ dB Step 4	S′ dB Step 5	$\overline{S}$ dB Step 6	SPL″ dB Step 7	*F* dB Step 8	*C* dB Step 9
1	50	—	—	—	—	—	—	—	—	—
2	63	—	—	—	—	—	—	—	—	—
3	80	70	—	—	70	–8	$-2\frac{1}{3}$	70	—	
4	100	62	–8	—	62	–8	$+3\frac{1}{3}$	$67\frac{2}{3}$	—	
5	125	(70)	+(8)	16	71	+9	$+6\frac{2}{3}$	71	—	
6	160	80	+10	2	80	+9	$+2\frac{2}{3}$	$77\frac{2}{3}$	$2\frac{1}{3}$	0.29
7	200	82	+(2)	8	82	+2	$-1\frac{1}{3}$	$80\frac{1}{3}$	$1\frac{2}{3}$	0.06
8	250	(83)	+1	1	79	–3	$-1\frac{1}{3}$	79	4	0.61
9	315	76	–(7)	8	76	–3	$+\frac{1}{3}$	$77\frac{2}{3}$	—	
10	400	(80)	+(4)	11	78	+2	+1	78	2	0.17
11	500	80	0	4	80	+2	0	79	—	
12	630	79	–1	1	79	–1	0	79	—	
13	800	78	–1	0	78	–1	$-\frac{1}{3}$	79	—	
14	1 000	80	+2	3	80	+2	$-\frac{2}{3}$	$78\frac{2}{3}$		
15	1 250	78	–2	4	78	–2	$-\frac{1}{3}$	78	—	
16	1 600	76	–2	0	76	–2	$+\frac{1}{3}$	$77\frac{2}{3}$	—	
17	2 000	79	+3	5	79	+3	+1	78		
18	2 500	(85)	+6	3	79	0	$-\frac{1}{3}$	79	6	2
19	3 150	79	–(6)	12	79	0	$-2\frac{2}{3}$	$78\frac{2}{3}$	—	
20	4 000	78	–1	5	78	–1	$-6\frac{1}{3}$	76	2	0.33
21	5 000	71	–(7)	6	71	–7	–8	$69\frac{2}{3}$	—	
22	6 300	60	–11	4	60	–11	$-8\frac{2}{3}$	$61\frac{2}{3}$	—	
23	8 000	54	–6	5	54	–6	–8	53		
24	10 000	45	–9	3	45	–9	—	45	—	
						–9				

Step 1	(3) (*i*) – (3) (*i* – 1)
Step 2	| (4) (*i*) – (4) (*i* – 1) |
Step 3	see instructions
Step 4	see instructions
Step 5	(6) (*i*) – (6) (*i* – 1)

Step 6	[(7) (*i*) + (7) (*i* + 1)+ (7) (*i* + 2)] ÷ 3
Step 7	(9) (*i* – 1) + (8) (*i* – 1)
Step 8	(3) (*i*) – (9) (*i*)
Step 9	see Table A2-2 of Appendix 2 of the Annex

Note.— Steps 5 and 6 may be eliminated in the calculations if desired. In this case in the example shown, columns (7) and (8) should be removed and existing columns (9), (10) and (11) become (7), (8) and (9) covering new steps 5, 6 and 7 respectively. The existing steps 5, 6, 7, 8 and 9 in 4.3.1 of Appendix 2 of the Annex are then replaced by:

STEP 5 [(6)(*i* – 1) + (6)*i* + (6)(*i* + 1)] ÷ *3*

STEP 6 (3)(*i*) – (7)(*i*) *if* > *0*

STEP 7 *See Table A2-2 of Appendix 2 of the Annex.*

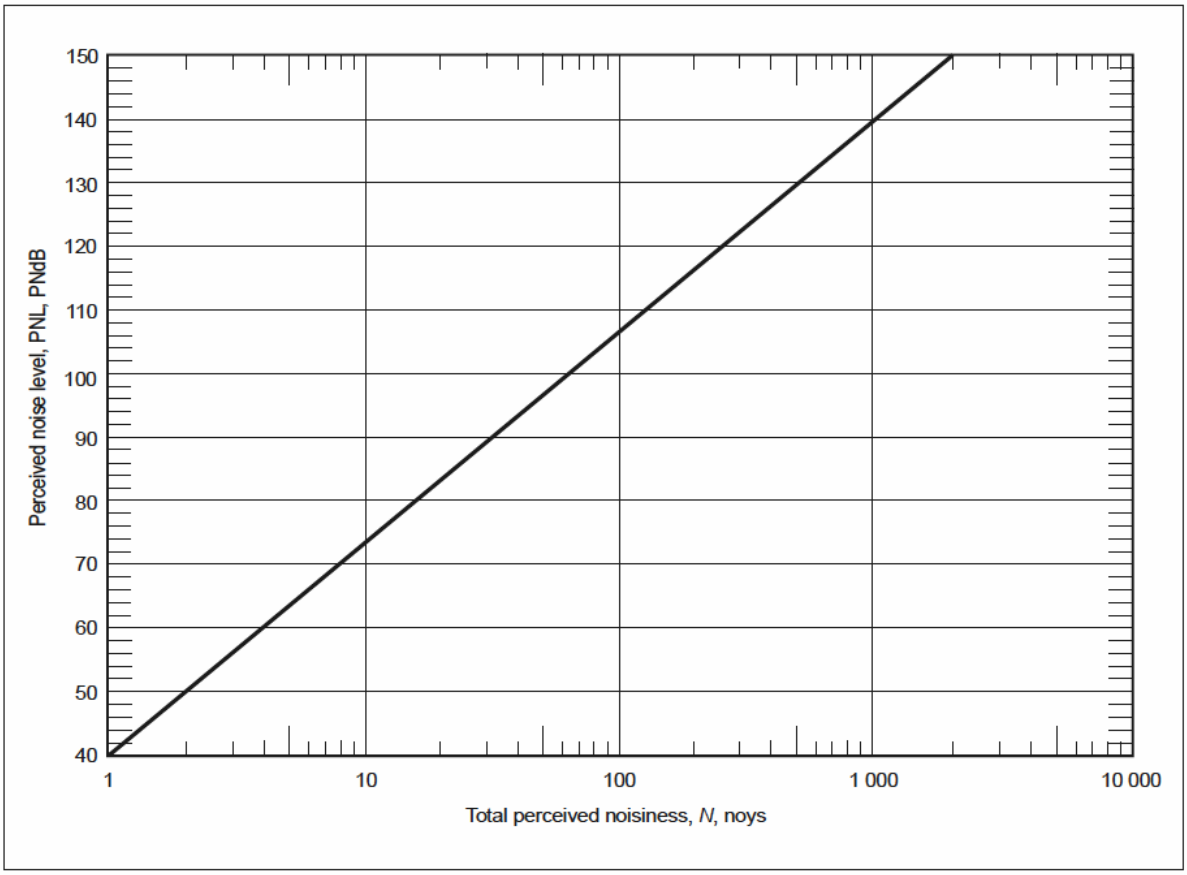


Figure 4-1. Perceived noise level as a function of total perceived noisiness

Appendix 5 - WORKED EXAMPLE OF CALCULATION OF REFERENCE FLYOVER HEIGHT AND REFERENCE CONDITIONS FOR SOURCE NOISE ADJUSTMENTS FOR CERTIFICATION OF LIGHT PROPELLER DRIVEN AEROPLANES TO ICAO ANNEX 16, VOLUME 1, CHAPTER 10

1. INTRODUCTION

The reference flyover height for an aeroplane certificated to Chapter 10 of Annex 16 is defined for a point 2500 m from start of roll beneath a reference flight path determined according to the take-off reference procedure described in Paragraph 10.5.2 of the Annex. An expression for the reference flyover height in terms of commonly approved performance data and an example of how such an expression may be worked are presented in this Appendix. The relationship between this reference height and the conditions to which source noise corrections are to be made is also explained.

2. TAKE-OFF REFERENCE PROCEDURE

The take-of reference procedure for an aeroplane certificated to Chapter 10 is defined under sea level, ISA conditions, at maximum take-off mass for which noise certification is requested, in Paragraph 10.5.2 of the Annex. The procedure is described in terms of two phases.

The first phase commences at "brakes release" and continues to the point where the aircraft has reached a height of 15 m (50 ft) above the runway (the point of interception of a vertical line passing through this point with a horizontal plane 15 m below is often referred to as "reference zero").

The second phase commences at the end of the first phase and assumes the aeroplane is in normal climb configuration with landing gear up and flap setting normal for "second segment" climb.

Note that in this respect the reference "acoustic" flight path ignores the "first segment" part of the flight path, during which the aircraft accelerates to normal climb speed and, where appropriate, landing gear and flaps are retracted.

3. EXPRESSION FOR REFERENCE HEIGHT

The reference flyover height is defined according to the take-off reference flight path at a point 2500 m from start of roll for an aeroplane taking-off from a paved, level runway under the following conditions:

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

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

$$H_R = (2500 - D_{15})\tan(\sin^{-1}(RC/V_y)) + 15 \qquad (1)$$

where: H_R is the reference height in metres;

D_{15} is the sea level, ISA take-off distance in metres to a height of 15 m at the maximum certificated take-off mass and maximum certificated take-off power;

RC is the sea level, ISA best rate of climb (m/s) at the maximum certificated take-off mass and the maximum power and rpm that can be continuously delivered by the engine(s) during this second phase; and

V_y is the best rate of climb speed (m/s) corresponding to RC.

The performance data in many flight manuals is often presented in terms of non SI units. Typically the take-off distance (expressed in feet) is given to a height of 50 ft, the rate of climb is expressed in feet per minute and the air speed in knots. In such instances the expression for reference flyover height, H_R ft, becomes:

$$H_R = (8203 - D_{50})\tan(\sin^{-1}(RC/101.4V_y)) + 50 \qquad (2)$$

where: D_{50} is the sea level, ISA take-off distance in feet to a height of 50 ft;

RC is the sea level, ISA best rate of climb (ft/m); and

V_y is the best rate of climb speed (kt).

The performance figures can normally found in the performance section of an aircraft's flight manual or pilot's handbook. Note that for certain categories of aircraft a safety factor may be applied to the take-off and climb performance

parameters presented in the flight manual. In the case of multi-engined aircraft it may be assumed that one engine is inoperative during part of Phase 1 and during Phase 2. For the purpose of calculating the "acoustic" reference flight path the take-off distance and rate of climb should be determined for all engines operating using gross, i.e. unfactored, data.

In addition, V_y, the best rate of climb speed, used in the expression above is defined as the true air speed (TAS). However, in the flight manual speed is normally presented in terms of indicated airspeed (IAS). This should be corrected to the calibrated airspeed (CAS) by applying the relevant position error and instrument corrections for the airspeed indicator. These corrections can also be found in the manual. For an ISA day at sea level the TAS is then equal to the CAS.

4. REFERENCE CONDITIONS FOR SOURCE NOISE ADJUSTMENTS

Paragraphs 5.2c and 5.2d of Appendix 6 of the Annex 16, Volume 1 describe how corrections for differences in source noise between test and reference conditions shall be made.

The reference helical tip Mach number and engine power are defined for the reference conditions above the measurement point, i.e. the reference atmospheric conditions at the reference height, H_R.

The reference temperature at this height is calculated under ISA conditions, i.e. for an ambient sea level

temperature of 15°C and assuming a standard temperature lapse rate of 1.98°C per 1000 ft. The reference temperature, T_R °C, can be defined as:

$$T_R = 15 - 1.98(H_R/1000) \tag{3}$$

The reference atmospheric pressure, P_R (hPa), is similarly calculated at the reference height for a standard sea level pressure of 1013.25 hPa assuming a standard pressure lapse rate:

$$P_R = 1013.25 - [1 - (6.7862 \times 10^6 H_R)]^{5.325} \tag{4}$$

5. WORKED EXAMPLE

A worked example is presented for the calculation of reference flyover

height and the associated reference atmospheric conditions.

5.1 Example of reference flyover height calculation

In Figure 5-1 extracts are presented from the performance section of a flight manual for a typical light, single engined propeller driven aeroplane.

The introduction contains a statement to the effect that the information is derived from "measured flight test data" and includes "no additional factors".

The take-off distance to 50 ft at the reference conditions of Chapter 10 can be read from the table of take-off distances presented for a paved runway at the maximum certificated take-off weight of 1920 lb. Thus D50 is 1370 ft.

The rate of climb at the reference conditions can similarly be read from the rate of climb table. Thus RC is 1000 ft/m.

The climb speed associated with the rate of climb figures is given as 80 kIAS. The corresponding true air speed at the reference conditions of Chapter 10 is equal to the indicated airspeed corrected according to the airspeed calibration table at the appropriate flap setting of 0°. Thus V_y is 81 kTAS.

Entering these parameters into the expression for reference height (ft) given in Equation 2 gives:

$$H_R = (8203 - 1370)\tan(\sin^{-1}(1000/101.4\times81)) + 50 = 888 \text{ ft}$$

5.2 Example of calculation of reference atmospheric conditions

The reference temperature at the reference height, HR, is given by Equation 3:

$$T_R = 15 - 1.98(888/1000) = 13.2ºC$$

The reference pressure at this height is given by Equation 4:

$$P_R = 1013.25 - [1 - (6.7862 \times 10^6 \times 888)]^{5.325} = 981 \text{ hPa}$$

SECTION 5

PERFORMANCE

1. INTRODUCTION

The data processed in this section enables flight planning to be carried out for flights between airfields with various altitudes, temperatures and field lengths. The information is derived from measured flight test data using CAA approved methods and factors to cover all the conditions shown. The data assumes average pilot skill and an aircraft engine and propeller in good condition.

No additional factors are included and it is the pilots responsibility to apply safety factors which must not be less than those.....

6. AIRSPEED CALIBRATION

0° Flap	**KIAS** KCAS	- -	60 61	70 71	**80 81**	90 91	100 101	110 111	120 121	130 131	180 181
15° Flap	KIAS KCAS	50 51	60 61	70 71	80 81	85 86	- -	- -	- -	- -	- -
35° Flap	KIAS KCAS	50 50	60 59	70 69	80 79	85 84	- -	- -	- -	- -	- -

TAKE-OFF DISTANCE - PAVED RUNWAY (1)
CONDITIONS
Flaps - 15°.....Rotation speed - 53 KIAS
Power - Full throttle.....Speed at 50 ft - 65 KIAS
Weight - 1920 lbs

AIRFIELD HEIGHT FT	ISA -20°C		ISA -10°C		**ISA**	
	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft	Grnd Roll	**Total to 50 ft**
Sea Level	530	1230	565	1290	600	**1370**
5000	1045	2835	1065	2435	1090	2580
10000	1465	3335	1490	3390	1510	3435
AIRFIELD HEIGHT FT	ISA +10°C		ISA +20°C		ISA +30°C	
	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft	Grnd Roll	Total to 50 ft
Sea Level	700	1580	750	1715	840	1900
5000	1170	2670	1295	2840	1290	2905
10000	1575	3560	1610	3695	1670	3790

RATE OF CLIMB
CONDITIONS
Flaps UP
Full throttle
Weight - 1920 lbs
Speed - 80 KIAS

PRESSURE ALTITUDE FT	RATE OF CLIMB FEET/MINUTE			
	ISA-20°C	ISA	ISA+10°C	ISA+20°C
Sea Level	1035	**1000**	915	825
1000	980	945	860	770
2000	925	890	805	720
3000	870	830	750	665
4000	815	775	695	610
5000	765	720	640	560
6000	700	665	585	505
7000	635	605	560	450
8000	570	550	475	395
9000	495	480	410	335
10000	415	405	335	270

Figure 5-1. Example of Flight Manual Performance Section

Appendix 6 - NOISE DATA CORRECTIONS FOR TESTS AT HIGH ALTITUDE TEST SITES

1. INTRODUCTION

Jet noise generation is somewhat suppressed at higher altitudes due to the difference in the engine jet velocity and jet velocity shear effects resulting from the change in air density. Use of a high altitude test site for the noise test of an aeroplane model that is primarily jet noise dominated should include making the following corrections. These jet source noise corrections are in addition to the standard pistonphone barometric pressure correction of about 0.1 dB/100 m (0.3 dB /1000 ft) which is normally used for test sites not approximately at sea level, and applies to tests conducted at sites at or above 366 m (1200 ft) mean sea level (MSL).

2. JET NOISE SOURCE CORRECTION

Flight test site locations at or above 366 m (1200 ft) MSL, but not above 1219 m (4000 ft) MSL, may be approved provided the following criteria (Figure 6-1) are met and source noise corrections (paragraph 2.3) are applied. Alternative criteria or corrections require the approval of the certificating authority.

2.1 Criteria

Jet source noise altitude corrections from paragraph 2.3 are required for each one-half second spectrum when using the integrated procedure and at the PNLTM spectrum when using the simplified procedure (see paragraph 9.3 and 9.4 of Appendix 2 of Annex 16, Volume 1), and are to be applied in accordance with the following criteria:

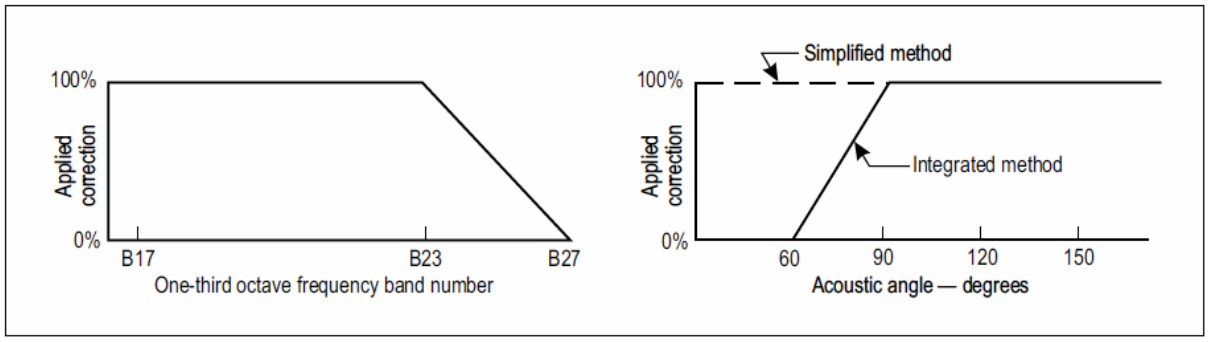


Figure A6-1. Criteria for jet noise source correction

2.2 Correction Procedure

An acceptable jet source noise correction is as follows:

a) Correct each one-half second spectrum (or PNLTM one-half second spectrum, as appropriate) in accordance with the criteria of paragraph 2.2 using the following equation:

$$\Delta SPL = [10\log(d_R/d_T) + 50\log(c_T/c_R) + 10k\log(u_R/u_T)][F1][F2]$$

where: Subscript T denotes conditions at the actual aeroplane test altitude above MSL under standard atmospheric conditions, i.e. ISA+10°C and 70% relative humidity;

Subscript R denotes conditions at the aeroplane reference altitude above MSL (i.e. aeroplane test altitude above MSL minus the test site altitude) under standard atmospheric conditions, i.e. ISA+10°C and 70% relative humidity;

d_R is the density for standard atmosphere at the aeroplane reference altitude in kg/m3 (lb/ft3);

d_T is the density for standard atmosphere at the aeroplane test altitude in kg/m3 (lb/ft3);

c_R is the speed of sound corresponding to the absolute temperature for standard atmosphere at aeroplane reference altitude in m/s (ft/s);

c_T is the speed of sound corresponding to the absolute temperature for standard atmosphere at aeroplane test altitude in m/s (ft/s);

k = 8, unless an otherwise empirically derived value is substantiated;

$u = (v_e - v_a)$ is the equivalent relative jet velocity in m/s (ft/s)

where: v_e is the equivalent jet velocity as defined in SAE ARP876D, Appendix C (January 1994) and obtained from the engine cycle deck in m/s (ft/s); and

v_a is the aircraft velocity in m/s (ft/s)

u_R is the equivalent relative jet velocity in m/s (ft/s) where v_e is determined at $N1C_{TEST}$ for standard atmosphere at the aeroplane reference altitude;

u_T is the equivalent relative jet velocity in m/s (ft/s) where v_e is determined at $N1C_{TEST}$ for standard atmosphere at the aeroplane test altitude;

N1C is the corrected engine rpm $\left(N_1 / \sqrt{\theta_{T_2}}\right)$;

F1 is a factor corresponding to the percentage of applied correction related to acoustic angle in Figure 6-1 (values range from 0.00 to 1.00); and

F2 is a factor corresponding to the percentage of applied correction related to the onethird octave band in Figure 6-1 (values range from 0.00 to 1.00).

b) For each one-third octave band SPL, arithmetically add the altitude jet noise correction in a) above to the measured SPL's to obtain the altitude source jet noise corrected SPL's for paragraph 4.1.3a of Appendix 2 of Annex 16, Volume 1.

c) The above altitude correction is to be applied to all measured test data including approach conditions (unless it can be substantiated that the jet noise during approach does not contribute significantly to the total aircraft noise).

Appendix 7 - TECHNICAL BACKGROUND INFORMATION ON THE GUIDELINES FOR THE NOISE CERTIFICATION OF TILTROTOR AIRCRAFT

[RESERVED]

Appendix 8 - REASSESSMENT CRITERIA FOR THE RE-CERTIFICATION OF AN AEROPLANE FROM ICAO ANNEX 16, VOLUME 1, CHAPTER 3 TO A MORE STRINGENT STANDARD

[RESERVED]

APPENDIX II – VNTSC Certification Validation Package

In order to effectively validate adjustment procedures used by applicants for aircraft noise certification, the Acoustics Facility of the Volpe National Transportation Systems Center ("VNTSC") requests that detailed information, as described herein, be supplied by each applicant. This information will be processed by VNTSC in accordance with the requirements of Federal Aviation Regulation (FAR) Part 36, to verify that the applicant's adjustment procedures are valid.

Applicants should note that the VNTSC requirements for the data sets to be supplied exceed (in some cases) the reporting requirements for certification. This is necessary for accurate duplication of the applicant's procedures and to obtain meaningful results for evaluation. Complete data sets are required for three representative events (test runs): one each for approach, takeoff, and sideline-takeoff types for fixed-wing aircraft, and one each for approach, takeoff, and level flyover for helicopters. In addition to the listed information, the applicant must provide completed copies of the attached data forms, with information for each of the three events.

Each applicant must provide the following data:

(1) A flow diagram and/or description of measurement, analysis and adjustment systems, including system characteristics.

(Data Form 1 must be completed.)

(2) An uncorrected, contiguous one-third-octave band sound pressure level time-history for each event (ANSI/ISO bands 17-40, nominal center frequencies of 50 Hz to 10 kHz, inclusive). The following must also be included:

(a) Time at the start of the first data record for each event (A common time base must be used to synchronize acoustic, tracking, and meteorological measurements)

(b) Elapsed time between data records

(c) Type of time-averaging (linear/exponential)

(d) Averaging period

(3) A one-third-octave-band data record of pre-detection noise, including

the ambient noise conditions at the test site, and electronic instrumentation noise floor (one for each event and site combination submitted).

(4) A one-third-octave band data record of the post-detection noise at the sensitivity settings at which the individual event was processed (one for each event/site/system combination submitted).

(5) Meteorological data (i.e., temperature and relative humidity) versus altitude (per event) as used in processing for determining propagation time, absorption, etc. A description of the meteorological data must be supplied, specifying any post-processing that was performed (such as smoothing, layering, time interpolation, or altitude extrapolation) on the measured data prior to reporting. The time-of-day associated with each meteorological data set must be provided.

(6) Aircraft position and performance data (TSPI - Time Space Position Information) for each event, including XYZ coordinates referenced to the centerline microphone location. A description of the tracking data must be supplied, specifying any post-processing that was performed (such as smoothing, curve-fitting, straight-line approximation, etc.) on the measured data prior to reporting. At a minimum the following performance data must be supplied:

(a) Aircraft altitude at overhead

(b) Ground speed [V_g]

(c) Climb/descent angle [Φ]

(d) X- and Y-offset or ground-track horizontal cross-angle [γ]

(e) Time at overhead [T_{oh}]

(See the attached Figure 1.)

Also, any additional elements used in the calculation of propagation distance, emission time, or emission angle, (such as yaw or pitch) must be specified, as well as the processes used to apply them.

(Data Form 2 must be completed.)

(7) Any adjustments to be applied to the raw one-third-octave-band spectral data, including:

(a) System adjustments for deviation from flat frequency response (pink noise test)

(b) Microphone pressure-response and free-field sensitivity adjustments (including incidence-dependent adjustments over a range of angles, if applicable)

(c) Microphone windscreen insertion loss adjustments

(d) Analyzer bandwidth error adjustments

(e) Calibrator drift adjustment

(f) Calibrator atmospheric pressure adjustment

(g) System gain-change adjustment

(h) Other adjustments, e.g., high-altitude jet noise adjustment

(8) A description of any adjustment process used to correct the acoustic data for background noise effects, including:

(a) Correction for effects of pre-detection noise

(b) Determination of masking criteria

(c) Type of reconstruction used for masked, high-frequency data (e.g., frequency and/or time extrapolation)

(d) Handling of masked low frequency data

(e) Identification of masked data

(f) Identification of non-valid records due to exceedance of masking limits.

(9) If used, a description of computer averaging applied to linear data to achieve Slow exponential response after analysis, including type of averaging and values for weighting (e.g., four-sample weighted logarithmic averaging with coefficients of n1, n2, n3, and n4).

(10) If reconstruction is performed using time and/or frequency extrapolation, or if the "Integrated" Procedure is used for adjustment to Reference-Day Conditions, a timehistory of processed aircraft geometric data (XYZ emission coordinates, emission angle, elevation angle, and propagation distance relative to the microphone, at time of emission for each acoustical data record within the EPNL duration).

(11) A description of the tone-correction process used, including any upper and lower frequency limits, exclusion of tones in masked bands, special

handling of pseudotones, etc.

(12) A time-history of Test-Day "adjusted as-measured", contiguous, one-third-octave band data records along with calculated PNL, and PNLT values, and frequency of maximum tone correction for each record. Additionally, the test-day EPNL, band-sharing adjustment, and time of PNLTmax record (as determined per FAR Part 36, Appendix A, A36.3.7.6) must be included. The PNLTmax record, the 10 dB down records, and secondary peaks within 2 dB of PNLTmax must also be identified.

(Data Form 3 must be completed.)

(13) Parameters used for adjustment to Reference Conditions, including:

(a) Reference altitude

(b) Reference ground speed [Vgref]

(c) Reference climb/descent angle [O| ref]

(d) Reference receiver offset from reference ground track

(Data Form 2 must be completed.)

(14) Identification of process to be validated for adjustment to Reference Conditions: "Simplified" Procedure, "Integrated" Procedure, or both.

(14.1) The following data are required for validation of the "Simplified" Procedure:

(a) $EPNL_{REF}$: Reference-Day EPNL

(b) Del(1)= Reference-Day $PNLT_{max}$ − test-day $PNLT_{max}$

(c) Del(2):

$$\text{fixed-wing} = -7.5\log(SR/SRR) + 10\log(V_g/V_{gref})$$

$$\text{helis} = -10\log(SR/SRR) + 10\log(V_g/V_{gref})$$

(d) Del(peak): correction resulting from secondary as-measured peaks within 2 dB of $PNLT_{max}$

(e) Del(bndshr): band sharing adjustment

(f) $PNLT_{maxREF}$: Reference-day $PNLT_{max}$

(g) For $PNLT_{max}$ and any peaks within 2 dB of $PNLT_{max}$, the following must be provided:

- Reference-Day PNL, PNLT, and maximum tone correction frequency band

- Reference-day one-third-octave-band spectrum

- Track data at emission time (i.e., slant range [SR_e]; emission angle [θ_e]; elevation angle [β_e]; XYZ coordinates; and reference slant range [SRR_e]

(Data Form 4a must be completed.)

(14.2) The following data are required for validation of the "Integrated" Procedure:

(a) $EPNL_{REF}$: Reference-day EPNL

(b) $PNLT_{maxREF}$: Reference-day $PNLT_{max}$

(c) Maximum tone correction value and frequency band for Reference-Day $PNLT_{max}$

(d) A time-history of Reference-Day, contiguous one-third-octave-band data records with calculated PNL, PNLT, maximum tone correction frequency, and the calculated effective duration time for each record

(e) A time-history of reference track coordinates at reference emission time (i.e., reference slant range [SRR_e]; and reference XYZ coordinates

(f) Identification of the Reference-Day $PNLT_{max}$ and 10 dB-down records

(g) $Del(bndshr)_{REF}$: Reference-Day band sharing adjustment

(Data Form 4b must be completed.)

Both hardcopy and electronic data file versions of all data are required. All noise level data must be provided to the nearest .01 dB.

A technical point-of-contact (name, telephone #, address, and email address) must be identified by each applicant.

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Form 1

MEASUREMENT & ANALYSIS SYSTEMS

APPLICANT _____

TEST DATE (MM/DD/YY) _____/_____/_____

AIRCRAFT DESIGNATION_____

Site ID		C1	S1	S2
Site Coordinates: Distances in Feet Relative to Site C1 (See Figure 1)	X	0.0		
	Y	0.0		
	Z	0.0		
Site Elevation (Feet MSL)				
Microphone Height (Feet AGL)				
Mic. Orientation re: Flight Path (ie: grazing, normal to CPA, normal to overhead, etc.)				
Microphone Manufacturer & Model				
Windscreen Manufacturer & Model				
Recorder Manufacturer & Model				
Calibrator Manufacturer & Model				
Analyzer Manufacturer & Model				
Analyzer Averaging Time Period				
Analyzer Avg. Mode (linear/exp.)				
Tone Correction Lower Limit (Hz)				
Other Adjustment(s)				

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Form 2

FLIGHT PERFORMANCE & OPERATION

APPLICANT _____

TEST DATE (MM/DD/YY) _____/_____/_____

AIRCRAFT DESIGNATION _____

Event ID				
Event Type (T/O, Approach, Sideline)				
Time at Overhead [T_{oh}] (HH:MM:SS.SS)				
Altitude at Overhead (Feet AGL)				
Reference Altitude (Feet AGL)				
Ground Speed [V_g] (Knots)				
Ref. Groundspeed [V_{gref}] (Knots)				
Climb/Descent Angle [Φ] (Degrees)				
Ref. Climb/Descent Angle [Φ_{ref}] (Deg.)				
Horizontal Cross Angle [γ] (Degrees)				
X Offset (Feet)				
Y Offset (Feet)				
Reference Microphone Coordinates (Feet)	X			
	Y			
	Z			

See Figure 1

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Form 3

DATA PROCESSING RESULTS - TEST-DAY "ADJUSTED AS-MEASURED"

APPLICANT _____

TEST DATE (MM/DD/YY) _____/_____/_____

AIRCRAFT DESIGNATION_____

Event ID			
Site ID			
Number of Raw Data Records			
Time @ Start of First Raw Data Record (HH:MM:SS.SS)			
Time @ $PNLT_{max}$ (HH:MM:SS.SS)*			
$PNLT_{max}$ Record Number			
First 10dB-down Record Number			
Last 10dB-down Record Number			
EPNL			
$PNLT_{max}$			
PNL_{max}			
LA_{max}			
Tone Correction Band @ $PNLT_{max}$			
Del(bndshr)			
Record Numbers of Peaks Within 2dB of $PNLT_{max}$			

*Time as determined per FAR Part 36, Appendix A, Section A36.3.7.6

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Form 4a

PROCESSING RESULTS - ADJUSTMENT TO REFERENCE CONDITIONS

"Simplified" Procedure

APPLICANT _____

TEST DATE (MM/DD/YY) _____/_____/_____

AIRCRAFT DESIGNATION_____

Event ID			
Site ID			
$PNLT_{max\ REF}$			
$EPNL_{REF}$			
Tone Correction @ $PNLT_{max\ REF}$			
Tone Correction Band @ $PNLT_{max\ REF}$			
Slant Range [SR_e] @ $PNLT_{max\ REF}$			
Ref. Slant Range [SRR_e] @ $PNLT_{max\ REF}$			
Emission Angle [Θ_e] @ $PNLT_{max\ REF}$			
Elevation Angle [β_e] @ $PNLT_{max\ REF}$			
X_e Coordinate @ $PNLT_{max\ REF}$			
Y_e Coordinate @ $PNLT_{max\ REF}$			
Z_e Coordinate @ $PNLT_{max\ REF}$			
Del(1)			
Del(2)			
Del(peak)			
Del(bndshr)			

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Form 4b

PROCESSING RESULTS - ADJUSTMENT TO REFERENCE CONDITIONS

"Integrated" Procedure

APPLICANT _____

TEST DATE (MM/DD/YY) _____/_____/_____

AIRCRAFT DESIGNATION_____

Event ID			
Site ID			
$PNLT_{max\ REF}$			
$EPNL_{REF}$			
Time @ $PNLT_{max\ REF}$ (HH:MM:SS.SS)			
$PNLT_{max\ REF}$ Record Number			
First 10dB-$down_{REF}$ Record Number			
Last 10dB-$down_{REF}$ Record Number			
Tone Correction @ $PNLT_{max\ REF}$			
Tone Correction Band @ $PNLT_{max\ REF}$			
Slant Range [SR_e] @ $PNLT_{max\ REF}$			
Ref. Slant Range [SRR_e] @ $PNLT_{max\ REF}$			
Emission Angle [Θ_e] @ $PNLT_{max\ REF}$			
Elevation Angle [β_e] @ $PNLT_{max\ REF}$			
X_e Coordinate @ $PNLT_{max\ REF}$			
Y_e Coordinate @ $PNLT_{max\ REF}$			
Z_e Coordinate @ $PNLT_{max\ REF}$			
Del(bndshr)REF			

Form 5
CHECKLIST

1. Complete Form 1

2. Supply Flow Diagram and/or description of measurement, analysis & adjustment systems.
   Letter Item 1

3. Supply 1/3 Octave Uncorrected Noise Data
   Letter Item 2

4. Supply 1/3 Octave Ambient Noise Data
   Letter Item 3

5. Supply 1/3 Octave Instrumentation Floor Noise Data
   Letter Item 4

6. Supply Meteorological Data
   Letter Item 5

7. Supply Aircraft Positional Data
   Letter Item 6

8. Complete Form 2

9. Supply 1/3 Octave System Adjustment (Pink Noise) Data
   Letter Item 7.a

10. Supply 1/3 Octave Microphone Sensitivity Adjustment Data
    Letter Item 7.b

11. Supply data and description of any other adjustments applied to obtain "adjusted as-measured" data, including procedures to correct for background noise effects.
    Letter Items 7 - 11

12. Supply 1/3 Octave Test-day "adjusted as-measured" Noise Data
    Letter Item 12

13. Complete Form 3

14. Supply description of computer processing characteristics and methodology used to adjust data to Reference conditions, including reference parameters.
    Letter Item 13

15. Supply 1/3 Octave Reference-day Noise Data:
    - Entire event, if using "integrated" procedure
    - $PNLT_{max}$ record (and records for peaks within 2dB of $PNLT_m$ if applicable), if using "simplified" procedure
    Letter Items 14.1.g/14.2.d

16. Supply Tracking Data:
    - Entire event, if using "integrated" procedure
    - $PNLT_{max}$ point (and records for peaks within 2dB of $PNLT_m$ if applicable), if using "simplified" procedure
    Letter Items 14.1.g/14.2.e

17. Complete Form 4

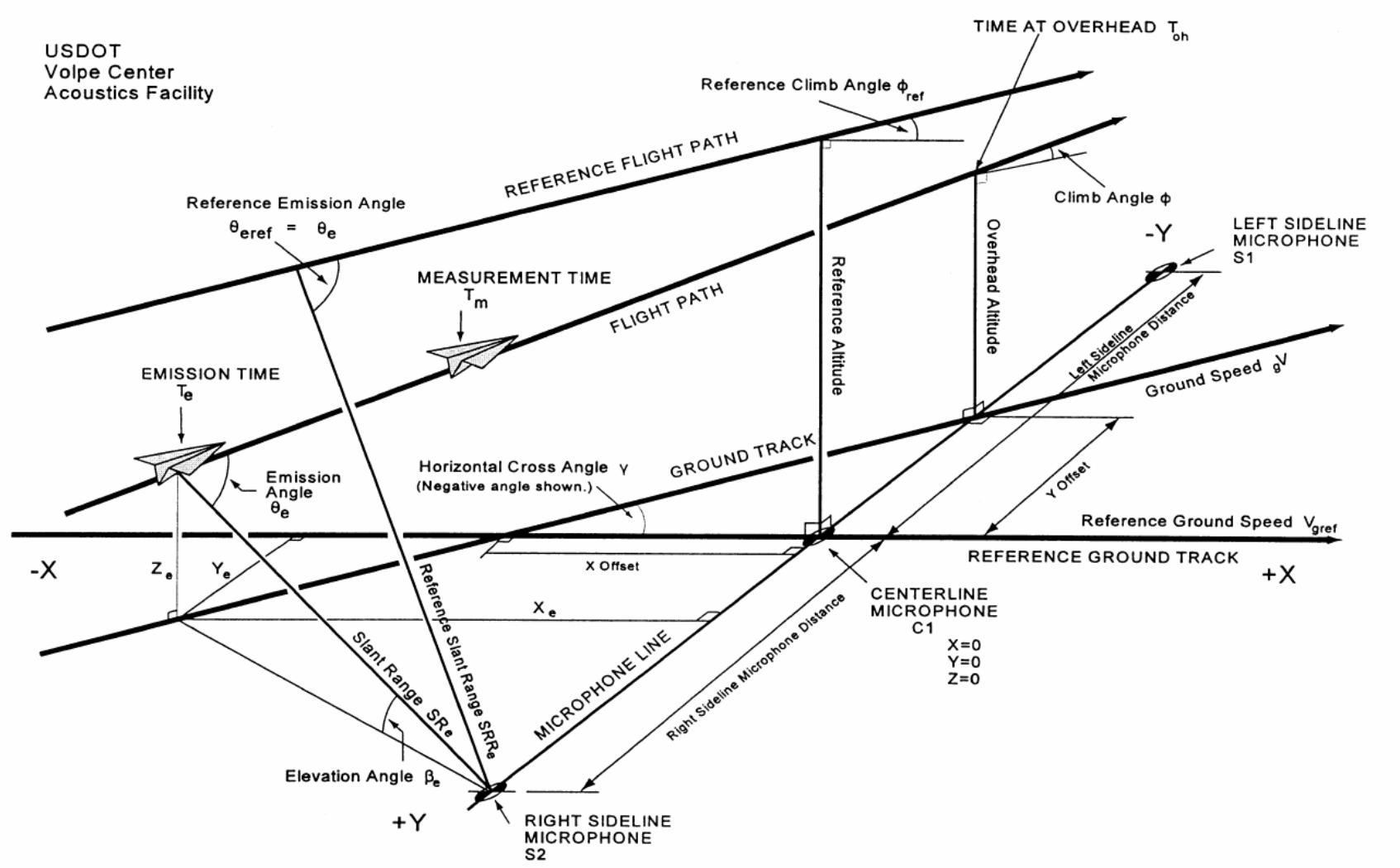


Figure 1. Aircraft and microphone geometry

APPENDIX III – Guidelines for Adjustment of Aircraft Noise Levels for the Effects of Background Noise

1.0 Introduction:

1.1 The following information is provided as guidance material on procedures for adjusting measured aircraft noise levels for the effects of background noise.

1.2 The presence of background noise during aircraft noise certification tests can influence measured aircraft sound levels, and in some cases, obscure portions of the spectral time history used to obtain EPNL values. Adjustment procedures must include the following components:

- Testing to determine which, if any, portions of the spectral time history are obscured.
- Adjusting unobscured levels to determine the aircraft sound levels that would have been measured in the absence of background noise.
- Replacing or reconstructing obscured levels by frequency extrapolation, time extrapolation, or by other means.

1.3 A list of definitions for terms used in this appendix is provided in Section 2.0. Although some of the terms have generally accepted meanings, the specific meanings as defined apply herein.

1.4 A detailed, step-by-step procedure is presented in Section 3.0, including equations and descriptions of time and frequency extrapolation methods (3.2.10). Other procedures may be used provided that they have been approved by the certificating authority.

1.5 General considerations, which apply to any background noise adjustment procedure, are listed in Section 4.0, including requirements and limitations (4.1) and other special considerations (4.2 through 4.4).

2.0 Definitions:

For purposes of this appendix, the following definitions apply:

- **adjusted (level):** a valid one-third-octave band level, which has been adjusted for measurement conditions, including:

1.) The energy contribution of pre-detection noise; and

2.) Frequency-dependent adjustments such as system frequency response, microphone pressure response and free-field response, and windscreen incidence-dependent insertion loss.

- **ambient noise:** the acoustical noise from sources other than the test aircraft present at the microphone site during aircraft noise measurements. 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 analog tape recorders; and digitization noise caused by quantization error in digital converters. Some elements of background noise, such as ambient noise, can contribute energy to the measured aircraft noise signal while others, such as digitization noise, can obscure the aircraft noise signal.
- **energy-subtraction:** subtraction of one sound pressure level from another, on an energy basis, in the form:

$$10\log_{10}\left[10^{(L_A/10)} - 10^{(L_B/10)}\right]$$

Where L_A and L_B are two sound pressure levels in decibels, L_B being the value subtracted from L_A.

- **frequency extrapolation:** a method for reconstruction of high frequency masked data, based on unmasked data in a lower-frequency one-third-octave band from the same spectrum. (See 3.2.10.a.)
- **high frequency bands:** the twelve bands from 800 Hz through 10 kHz inclusive. (See also "low frequency bands".)
- **LGB (Last Good Band):** in the adjustment methodology presented in Section 3.0, for any aircraft one-third-octave band spectrum, the highest-frequency unmasked band within the range of 630 Hz to 10 kHz inclusive, below which there are no masked high frequency bands
- **low frequency bands:** the twelve bands from 50 Hz through 630 Hz

inclusive. (See “high frequency bands”.)

- **masked (band):** within a single spectrum, any one-third-octave band containing a masked level.
- **masked (level):** any one-third-octave band level which is less than or equal to the masking criterion for that band. When a level is identified as being masked, the actual level of aircraft noise in that band has been obscured by background noise and cannot be determined. Masked levels can be reconstructed using frequency extrapolation, time extrapolation, or other methods.
- **masking criteria:** the spectrum of one-third-octave band levels below which measured aircraft sound pressure levels are considered to be masked or obscured by background noise. Masking criteria levels are defined as the greater of:

  1.) pre-detection noise +3 dB; or

  2.) post-detection noise +1 dB.
- **post-detection noise:** the minimum levels below which measured noise levels are not considered valid. Usually determined by the baseline of an analysis “window”, or by amplitude non-linearity characteristics of components in the measurement and analysis system. Post-detection noise levels are non-additive, i.e., they do not contribute energy to measured aircraft noise levels.
- **pre-detection noise:** any noise which can contribute energy to the measured levels of sound produced by the aircraft, including ambient noise present at the microphone site and active instrumentation noise present in the measurement, recording / reproducing, and analysis systems.
- **reconstructed (level):** a level, calculated by frequency extrapolation, time extrapolation, or by other means, which replaces the measured value for a masked band.
- **time extrapolation:** a method for reconstruction of high frequency masked data, based on unmasked data in the same one-third-octave band, from a different spectrum in the timehistory. (See 3.2.10.b.)
- **valid or unmasked (band):** within a single spectrum, any one-third-octave band containing a valid level.

- **valid or unmasked (level):** any one-third-octave band level which exceeds the masking criterion for that band.

3.0 Background noise adjustment procedure

3.1 Assumptions:

- A typical aircraft spectrum measured on the ground contains one-third-octave band levels which decrease in amplitude with increasing frequency. This characteristic high frequency roll-off is due primarily to the effects of atmospheric absorption.
- A typical electronic instrumentation floor spectrum contains one-third-octave band levels which increase in amplitude with increasing frequency.
- Due to the aforementioned assumptions, as the observed frequency is increased within a onethird-octave band aircraft spectrum, and once a band becomes masked, all subsequent higherfrequency bands will also be masked. This allows the implementation of a "Last Good Band" (LGB) label to identify the frequency band above which the bands in a spectrum are masked.
- If, on occasion, a valid level occurs in a band of higher frequency than LGB, its presence will most likely be due to small variations in the pre-detection levels, and/or because the levels of the measured aircraft one-third-octave band spectrum are close to the levels of the background noise in general, and therefore its energy contribution will not be significant (This assumption is only valid in the absence of significant aircraft-generated tones in the region of masking). Therefore, the possibility of a level being valid in a band of higher frequency than LGB may be ignored. Applicants who prefer to implement algorithms for identifying and handling such situations may do so, but no procedure may be used without prior approval from the certificating authority.

3.2 Step-by-step description:

3.2.1 Determination of pre-detection noise: a time-averaged one-third-octave band spectrum of predetection noise levels for each test run (or group of runs occurring during a short time period) should be obtained by recording and analyzing ambient noise over a representative period of

time (at least 30 seconds in duration). Care should be taken to ensure that this ambient noise sample reasonably represents that which is present during measured aircraft runs. In recording ambient noise, all gain stages and attenuators should be set as they would be during the aircraft runs to ensure that the instrumentation noise is also representative. If multiple gain settings are required for aircraft noise measurements, a separate ambient sample should be recorded at each setting used.

3.2.2 Determination of post-detection noise: a one-third-octave band spectrum of post-detection noise levels should be determined as a result of testing (or from manufacturer's specifications), for each measurement / analysis configuration used (including different gain and / or sensitivity settings). Minimum valid levels may be determined on the basis of display limitations (e.g., blanking of the displayed indication when levels fall below a certain value), amplitude non-linearity, or other non-additive limitations. In cases where more than one component or stage of the measurement / analysis system imposes a set of minimum valid levels, the most restrictive in each one-third-octave band should be used.

3.2.3 Testing of pre-detection noise versus post-detection noise: the validity of pre-detection noise levels must be established before these levels can be used to adjust valid aircraft noise levels. Any pre-detection noise level which is equal to or less than the post-detection noise level in a particular one-third-octave band should be identified as invalid, and therefore should not be used in the adjustment procedure.

3.2.4 Determination of masking criteria: once the pre-detection noise and post-detection noise spectra are established, the masking criteria can be identified. For each one-third-octave band, compare the valid pre-detection noise level +3 dB with the post-detection noise level +1 dB. The highest of these levels is used as the masking criterion for that band. If there is no valid pre-detection noise level for a particular one-third-octave band, then the post-detection noise level +1 dB is used as the masking criterion for that band. The 3 dB window above predetection levels allows for the doubling of energy which could occur if an aircraft noise level were equal to the pre-detection level. The 1 dB window above the post-detection levels allows for a reasonable amount of error in the determination of those levels.

3.2.5 Identification of masked levels: each spectrum in the aircraft noise time-history can be evaluated for masking by comparing the

one-third-octave band levels against the masking criteria levels. Whenever the aircraft level in a particular band is less than or equal to the associated masking criterion, that aircraft level is considered masked. A record must be kept of which bands in each spectrum are masked.

3.2.6 Determination of Last Good Band: for each ½-second spectral record, determine the highestfrequency unmasked one-third-octave band ("Last Good Band" or "LGB") by starting at the 630 Hz band and incrementing the band number (increasing frequency) until a masked band is found. At that point, set LGB for that spectral record equal to the band below the masked band. The lowest-frequency band that can be identified as LGB is the 630 Hz band. In other words, if both the 630 Hz band and the 800 Hz band are masked, no reconstruction of masked levels may be performed for that spectrum, and the thirteen bands between 630 Hz and 10 kHz inclusive should be left as-is and identified as masked. Per the masking limits specified in Section 4.2.1 of this Appendix, such a spectrum is not valid for calculation of EPNL.

3.2.7 Adjustment of valid levels for background noise: in each ½-second spectrum, for each valid band up to and including LGB, perform an energy-subtraction of the valid pre-detection level from the valid measured level in the aircraft noise time-history:

$$10\log_{10}\left[10^{(L_{AIRCRAFT}/10)} - 10^{(L_{PRE-DETECTION}/10)}\right]$$

Energy-subtraction should be performed on all valid one-third-octave band noise levels. For any one-third-octave band where there is no valid pre-detection noise level, no energysubtraction may be performed, i.e., this adjustment cannot be applied when either the measured aircraft noise time-history level or the pre-detection noise level is masked.

3.2.8 Adjustment of valid levels for measurement conditions: before any reconstruction can be done for masked levels, valid levels which have been adjusted for the presence of pre-detection noise must also then be adjusted for frequency-dependent adjustments such as: system frequency response, microphone pressure response and free-field response, and windscreen incidence-dependent insertion loss. These adjustments can not be applied to masked levels.

3.2.9 Reconstruction of low frequency masked bands: for cases where a single masked low frequency one-third-octave band occurs between two adjacent

valid bands, the masked level can be retained, or the adjusted levels of the adjacent valid bands may be arithmetically averaged, and the averaged level used in place of the masked level. If the average is used, the level should be categorized as reconstructed. However, if masked low frequency bands are found adjacent to other masked low frequency bands, these masked levels should be retained and remain categorized as masked. The procedure presented in this Appendix does not provide for any other form of reconstruction for masked low frequency bands.

3.2.10 Reconstruction of levels for masked high frequency bands: frequency extrapolation and time extrapolation are the methods used to reconstruct masked one-third-octave band levels for bands at higher frequencies than LGB for each spectral record. One-third-octave band atmospheric absorption coefficients (in either dB per 1000 feet, or as used in the example below, dB per 100 m) must be determined before such reconstruction of masked band levels can be performed. Note that noise emission coordinates must also be calculated for each record before reconstruction is performed, since the procedure is dependent on propagation distance.

3.2.10.a For a spectrum where LGB is located at or above the 2 kHz one-third-octave band, use the frequency extrapolation method. This method reconstructs masked high frequency bands starting with the level associated with LGB (in the same spectrum). The levels for all bands at higher frequencies than LGB must be reconstructed using this method. Any frequency-extrapolated levels should be categorized as reconstructed. Reconstruct the level for the masked bands using the following equation:

$$Lx_{i,k} = L_{j,k} + \alpha_j \times \frac{SR_k}{100} - \alpha_{j_{REF}} \times \frac{60}{100} + 20\log_{10}\frac{SR_k}{60} + \alpha_{i_{REF}} \times \frac{60}{100} - \alpha_i \times \frac{SR_k}{100} + 20\log_{10}\frac{60}{SR_k}$$

Which can be reduced to:

$$Lx_{i,k} = L_{j,k} + \left[\alpha_j - \alpha_i\right] \times \frac{SR_k}{100} + \left[\alpha_{i_{REF}} - \alpha_{j_{REF}}\right] \times \frac{60}{100}$$

Where:

i is the masked band to be extrapolated

k is the record of interest

j is the Last Good Band (LGB) in record k

$Lx_{i,k}$ is the frequency-extrapolated level in dB for masked band *i* and spectral record *k*;

$L_{j,k}$ is the level for LGB in record k after all test-day adjustments have been applied, including pre-detection noise energy-subtraction, system and microphone adjustments, etc.

a_j is the test day atmospheric absorption coefficient (dB per 100 m) for LGB;

a_i is the test day atmospheric absorption coefficient (dB per 100 m) for band i;

$\alpha_{j_{REF}}$ is the reference (25°C, 70%RH) atmospheric absorption coefficient (dB per 100 m) for LGB

$\alpha_{i_{REF}}$ is the reference (25°C, 70%RH) atmospheric absorption coefficient (dB per 100 m) for masked band *i*

SR_k is the slant range or acoustic propagation distance in meters at the time of noise emission for spectral record *k*, between the aircraft and the microphone.

This procedure is based on the assumption that the aircraft spectrum is "flat" (all high frequency band levels are equal) at a distance of 60 meters under reference conditions (25°C, 70%RH). The process can be conceptualized by means of the following steps:

1. The level for band *j* (the highest-frequency unmasked band in spectral record *k*), which has already been adjusted for measurement conditions, is adjusted for test day propagation effects, to obtain the source level, then for reference propagation to the 60-meter distance from the source.
2. This level is then assigned as the level for all high frequency masked bands (band *i*, band *i*+1, etc.) at a distance of 60 meters.
3. A new source level is determined for each masked high frequency band by removing the associated reference day propagation effects.
4. The extrapolated level that would have been measured on the ground, in the absence of background noise, is determined for each masked high frequency band by adding the test day propagation effects to each of the source levels determined in step 3.

3.2.10.b For a spectrum where LGB occurs at or between the 630 Hz

one-third-octave band and the 1.6 kHz band, use the time extrapolation method. This method reconstructs a masked band in a spectrum from the closest spectral record (i.e., closest in time) for which that band is valid. The levels for all one-third-octave bands having frequencies greater than that of LGB must be reconstructed using this method. Any time extrapolated levels should be categorized as reconstructed. Reconstruct the levels for the masked bands using the following equation:

$$Lx_{i,k} = L_{i,m} + \left[\frac{SR_m}{100} - \frac{SR_k}{100}\right] \times \alpha_i + 20\log_{10}\left[\frac{SR_m}{SR_k}\right]$$

Where

$Lx_{i,k}$ is the time-extrapolated level in dB for band i and spectral record k;

$L_{i,m}$ is the adjusted level in dB for band i in spectral record m, which is the nearest record in time to record k in which band i contains a valid level;

SR_m is the slant range or acoustic propagation distance in meters at the time of noise emission for spectral record m, between the aircraft and the microphone;

SR_k is the slant range or acoustic propagation distance in meters at the time of noise emission for spectral record k, between the aircraft and the microphone; and

a_i is the test day atmospheric absorption coefficient (dB per 100 m) for band i.

This procedure is based on the assumption that the aircraft spectrum is omnidirectional during the aircraft passby.

3.3 After reconstruction of masked data has been performed, the background noise adjustment procedure is complete. The adjusted as-measured data set, comprised of adjusted levels, reconstructed levels, and possibly some masked levels, is next used to obtain the test day PNLT time-history described in FAR Part 36, Appendix A, Section A36.4. The identification of masked data should be kept accessible for use during the tone-correction procedure, since any tone correction which results from the adjustment for background noise may be eliminated from the process of identifying the maximum tone within a spectrum. When this background noise adjustment

procedure is used, the band identified as LGB should be treated as the last band of the tone-correction calculation, in the manner prescribed for the 10 kHz band in FAR Part 36, Appendix A, Section A36.4.3.1, including the calculation of a new slope for band LGB+1 that equals the slope at LGB (i.e.: $s'(\mathrm{LGB}+1,k)=s'(\mathrm{LGB},k)$, in Step 5 of the tone correction procedure).

4.0 General Considerations

4.1 Limitations and requirements for any background noise adjustment procedure: Any method of adjusting for the effects of background noise must be approved by the certificating authority before being used. The adjustment procedure presented in Section 3.2 of this appendix includes applicable limitations and requirements. Those limitations and requirements which apply to all methodologies are described below:

4.1.1 The applicant must be able to demonstrate that no significant aircraft-generated tones occur in masked one-third-octave bands during the EPNL duration by means of narrow-band analysis or other methods.

4.1.2 Neither frequency-dependent adjustments nor energy-subtraction of pre-detection levels can be applied to masked data.

4.1.3 Whenever levels at or below 0 dB occur, whether as part of the original analysis or as a result of the background noise adjustment procedure, their values must be maintained and included in all relevant calculations. Such levels can become significant during the adjustment of test data to reference conditions, especially over long propagation distances, where the effects of atmospheric absorption on higher frequency data can produce large one-third-octave band adjustments.

4.1.4 When consecutive one-third-octave bands in the range of 2.5 kHz to 10 kHz inclusive are masked, and when no consecutive bands are masked in the region of 800 Hz to 2 kHz inclusive, frequency extrapolation (as described in Section 3.2.10.a) must be performed on all consecutive masked bands having nominal frequencies greater than 2 kHz.

4.1.5 When consecutive one-third-octave bands in the range of 800 Hz to 2 kHz inclusive are masked, time extrapolation (as described in Section 3.2.10.b) must be performed on all consecutive, masked bands having nominal frequencies greater than 630 Hz.

4.1.6 For cases where a single masked one-third-octave band occurs between

two adjacent valid bands, the levels of the adjacent adjusted bands may be arithmetically averaged, and the averaged level used in place of the masked level. If the masked level is retained, it must be included in the count of masked levels in Section 4.2.

4.2 Rejection of spectra due to masking: the following conditions render a spectrum invalid (Note: If an invalid spectrum occurs within the 10 dB-down period, the aircraft test run is invalid, and cannot be used for aircraft noise certification purposes):

4.2.1 If, after any reconstruction of masked bands, more than four one-third-octave bands retain masked values.

4.2.2 For records within one second of the record associated with the PNLTmax spectrum (five ½-second data records), if more than four high frequency bands require reconstruction, or if LGB is located at or below the 4 kHz one-third-octave band when the example background noise adjustment procedure presented in Section 3.2 of this appendix is used.

4.3 Special tone-correction considerations due to masking: When the maximum tone-correction for a one-third-octave band spectrum occurs at a masked or reconstructed band, the tone-correction for that spectrum cannot simply be set to zero. The maximum tone-correction for the spectrum must be computed, taking masked or reconstructed levels into consideration. Any tone correction resulting from adjustment for background noise may be eliminated by one of the following two methods as appropriate:

4.3.1 When the example background noise adjustment procedure presented in Section 3.2 of this appendix is used (or specifically, when all of the high frequency bands in a spectrum are masked for frequencies beyond a certain band, "LGB"), the band labeled as LGB should be treated as the last band of the tone-correction calculation, in the manner prescribed for the 10 kHz band in FAR Part 36, Appendix A, Section A36.4.3.1, including calculation of a new slope for the band above LGB that equals the slope of the band at LGB ($s'(\mathrm{LGB}+1,k)=s'(\mathrm{LGB},k)$) in Step 5 of the tone-correction procedure.

4.3.2 For tone-corrections that occur at one-third-octave bands that are masked or reconstructed, set F equal to 0 in Step 9 of the tone-correction procedure, and recalculate the maximum tone-correction for that spectrum.

Note that all band levels within a spectrum, whether adjusted, reconstructed, or masked, must be included in the computation of the PNL value for that spectrum.

4.4 Handling of masked data in reference conditions data set: for any one-third-octave band spectrum adjusted to reference conditions, all bands, including those containing masked levels or reconstructed levels (including values less than 0 dB) must be adjusted for differences between test and reference conditions (i.e., atmospheric absorption and spherical spreading). The special tone-correction considerations listed in Section 3.2 of this appendix apply to both test and reference data sets.

Appendix IV - EQUIVALENT PROCEDURES AND DEMONSTRATING "NO ACOUSTICAL CHANGE" FOR PROPELLER-DRIVEN SMALL AIRPLANES AND COMMUTER CATEGORY AIRPLANES

1. Equivalent Procedures

Equivalent Procedures, as referred to in this AC, are aircraft measurement, flight test, analytical or evaluation methods that differ from the methods specified in the text of part 36 Appendices A and B, but yield essentially the same noise levels. Equivalent procedures must be approved by the FAA. Equivalent procedures provide some flexibility for the applicant in conducting noise certification, and may be approved for the convenience of an applicant in conducting measurements that are not strictly in accordance with the 14 CFR part 36 procedures, or when a departure from the specifics of part 36 is necessitated by field conditions.

The FAA's Office of Environment and Energy (AEE) must approve all new equivalent procedures. Subsequent use of previously approved equivalent procedures such as flight intercept typically do not need FAA approval.

2. Acoustical Changes

An acoustical change in the type design of an airplane is defined in 14 CFR section 21.93(b) as any voluntary change in the type design of an airplane which may increase its noise level; note that a change in design that decreases its noise level is not an acoustical change in terms of the rule. This efinition in section 21.93(b) differs from an earlier definition that applied to propeller-driven small airplanes certificated under 14 CFR part 36 Appendix F. In the earlier definition, acoustical changes were restricted to (i) any change or removal of a muffler or other component of an exhaust system designed for noise control, or (ii) any change to an engine or propeller installation which would increase maximum continuous power or propeller tip speed.

The definition of acoustical change in section 21.93(b) for propeller-driven small airplanes and commuter category airplanes is more in line with that for other aircraft categories. For example, an increase in takeoff weight without any change in engine/propeller installation would not be considered an acoustical change under the earlier definition. Now it would be, since the reference height

for noise level measurement would be lower with the increased weight, which would result in a higher noise level.

Section 36.9 defines the noise compliance requirements for propeller-driven small airplanes and commuter category airplanes for which an acoustical change approval is applied for under section 21.93(b). Section 36.9 recognizes two airplane categories: those that have previously been shown to comply with part 36, and those that have not. For the first group, any acoustical change must not increase noise levels beyond the limits stated in Part D of Appendix G. For the second group, noise levels may not exceed either these same limits, or "the noise level created prior to the change in type design, measured and corrected as prescribed in § 36.501 of this part," whichever is greater. Section 36.501(c) also requires that "compliance must be shown with noise levels as measured and prescribed in Parts B and C of Appendix G, or under approved equivalent procedures."

The FAA considers any change in type design that will increase the noise level by 0.1 dB or more an acoustical change. However, no acoustical change results as long as any change that can be expected to increase noise level is offset by other changes in design or performance that will decrease noise level in such a way that the sum of the changes does not increase the expected noise level by 0.1 dB. The purpose of this supplement is to examine methods for calculating changes in noise level introduced by common type design changes and methods for showing compensating noise level effects that will result in a demonstration of "no acoustical change."

3. Factors That Change Noise Level

Noise levels under Appendix G test procedures are affected by both the basic noise producing properties of the propeller/engine installation and by the takeoff and climb performance of the airplane. Regardless of what mechanical change is made to the airplane, noise levels can be expected to increase if any of the following conditions results from a type design change (without compensating changes):

a. Decrease in the height of the airplane at the reference distance of 8200 feet (2500 m) from brake release;

b. Increase in engine horsepower;

c. Removal or alteration of exhaust mufflers;

d. Increase in propeller helical tip Mach number;

e. Increase in propeller tip thickness;

f. Decrease in airplane climb path angle;

g. Increase in airplane drag;

i. Increase in inflow angle;

j. Change in blade number.

Increases expected in the Appendix G noise levels caused by any of the above changes must be offset by a compensating change if "no acoustical change" is claimed, and an appropriate analysis must be provided. Removal of exhaust mufflers or other changes in the exhaust system may require some form of testing to determine the acoustical effect. Similarly, increasing propeller tip thickness, such as by cutting the tips off an existing propeller to decrease its diameter, may cause an increase in noise level (which might be offset by the decrease in the propeller rotational Mach number at the same rpm). In both the case of the altered exhaust system and that for the cut-down propeller, a simple comparison test, during which noise levels are measured for the modified and the unmodified airplanes utilizing flybys at the same height and airspeed, may be approved as a satisfactory equivalent test procedure.

Comparison tests are not generally cost saving methods since they may become as complex as a full part 36 Appendix G test.

4. Examples of Type Design Changes That May Affect Noise Levels

Typical applications for type design changes that require an evaluation of the effect of the change on noise levels include:

a. Increase in takeoff weight without any change in engine or propeller installation.

b. Change from a fixed pitch propeller to a variable pitch propeller.

c. Change in propeller diameter.

d. Change in number of blades.

e. Increase in engine horsepower.

f. Modification that increases drag without any change in engine or propeller installations. Examples include installation of external cargo

containers, larger tires on fixed gear, or advertising light arrays.

In many cases, changes in noise level introduced by these modifications can be determined analytically by using existing data for the unmodified airplane, or by supplementing the existing data with additional performance information. Most requests for supplemental type certificates (STC) are made by applicants that do not have access to manufacturer's noise level data, even if these data exist. Since part 36 Appendix G applies to noise certification tests completed after December 1988, much of the existing fleet of small propeller airplanes do not have noise level data evaluated according to part 36 Appendix G. In order to obtain an STC, an applicant must demonstrate "no acoustical change" or conduct an entire Appendix G test. Several examples are given here of ways to demonstrate compliance using the adjustment factors described previously.

There are, however, some design changes which an applicant might argue that Appendix G compliance is not required, based on similarity to previously approved type certificates (TC) or STCs. Examples of this are older airplanes in a series where the series has several different engine sizes certified in the same basic airframe. Converting an airplane from one engine power to higher engine power by an applicant for an STC will require the applicant to do a noise analysis, possibly including noise measurements, even though the same engine/airframe combination exists in a production series. The reason for this is that the manufacturer is very unlikely to have demonstrated 14 CFR part 36 Appendix G compliance with any of his production airplanes. Even if the manufacturer has demonstrated compliance and the certificated noise level is published in an FAA Advisory Circular, the data used to demonstrate compliance, including the 90 percent confidence level for the certificated noise level, is proprietary to the manufacturer.

Before the adoption of Appendix G, certain changes to an airplane were accepted as "no acoustical change" by the FAA without any analysis. Two examples are the replacement of a two-blade propeller with a three-blade propeller, and an increase of less than 2 percent takeoff weight. For the reasons described below, these two types of changes are no longer accepted as "no acoustical change" unless the "no acoustical change" is substantiated by analysis and/or test data.

In the case of propeller replacements with increased number of blades, the change in noise generating mechanisms cannot be simply accounted for by tip Mach number and engine power corrections. Also, the increase in the number of

propeller blades shifts the blade passage to higher frequency, which has a smaller A-weighing filter adjustment. In STC applications with propeller changes, the FAA may require a comprehensive “no acoustical change” analysis to account for the modified noise generation mechanisms, and the A-weighing filter effects or flyover tests have to be conducted.

Increasing the maximum certificated takeoff weight over the base airplane (or aerodynamic changes which increase drag of the aircraft such that its takeoff performance deteriorates) would cause it to fly at a lower height over the noise measurement location, which results in a higher noise level. An increase in takeoff weight without any change in engine/propeller performance would be an acoustical change unless the noise increase is offset by performance gains or reduction in airplane noise generation, any of which must be substantiated by analysis and/or test data. It is possible to show a "no acoustical change" condition analytically as given Example 1 of this supplement, without actual field-testing.

4.1 Increase in Weight

For a change in airplane takeoff weight without any change in engine/propeller installation, the following factors influence the noise level under 14 CFR part 36 Appendix G procedures.

a. As a reasonable approximation, the takeoff distance to a height of 50 feet is increased by a factor equal to the square of the ratio of the weight after the change to the weight before the change.

b. The best-rate-of climb speed will increase essentially as the square root of the ratio of the weight before and after the change.

c. The climb angle at the increased weight will be lower.

The noise level produced at the higher weight will be greater than at the lower weight because these items combine to generate a lower reference height. The increase in airspeed can also cause a modest change in the reference helical tip Mach number, which may increase noise level.

The incremental change in noise level, if nothing else is done, can be shown by an example. Note that the subscript "b" is used to denote the "before" conditions and the subscript "a" is used to denote the "after" condition.

The following examples are provided to give applicants guidance for “no acoustical change” analysis. The performance calculations used in the examples

are for demonstration purposes only; they are not FAA approved performance calculation procedures. Any change in performance data (takeoff or climb) that is to be utilized in the determination of "no acoustical change" must be published in the aircraft flight manual.

Example 1: Calculate the change in noise level expected if the weight of an airplane increases from 3,000 lbs to 3,200 lbs, without any other changes, given the following (note that all of the data given is readily available or is calculable from virtually all aircraft operations handbooks):

D_{50} = 2220 ft, distance to 50 feet altitude

V_y = 90 kts, speed for best-rate-of climb

R_c = 970 ft/min, best rate of climb

$\gamma = \sin^{-1}(R_c/V_y) = \sin^{-1}[970/(60\times1.688\times90)] = 6.11°$, climb angle (1)

$h = \tan(\gamma)(8200 – D50) + 50 = \tan(6.11°)\ (8200 – 2220) + 50$

$= 690$ ft, reference altitude over the prescribed measurement location (2)

D = 84 in, propeller diameter

rpm = 2600 rpm, propeller speed

$T = 59(°F) - \text{lapse rate} \times h = 59(°F) - 0.003566 \times 690$

$= 56.5°F$, air temperature at reference altitude (3)

c = 49.025 x (T + 459.67)1/2

= 1113.8 ft/s, speed of sound at reference altitude equation (4)

$D = (1 - 0.0000068753 \times h)^{5.2561}$

= 0.99518, pressure ratio at reference altitude equation (5)

q = (T + 459.67) / (59(°F) + 459.67)

= 0.99518, temperature ratio at reference altitude (6)

s = D/q, density ratio (7)

$V_{tas} = V_y/\sigma^{1/2}$

= 90.9 knots, true airspeed of aircraft equation (8)

$M = V_{tas}/c$

$= 1.688 \times 90.9 / 1113.8 = 0.1378$, aircraft Mach speed (9)

$M_R = D \times rpm / (60 \times 12 \times c)$

$= 0.8556$, propeller rotational Mach number (10)

$M_h = (M^2 + M_R^2)^{1/2} = 0.8666$, helical tip Mach number (11)

Step 1: Calculate the reference height for a weight of 3200 lbs.

a. The takeoff distance before the change, $D_{50}(b)$, is 2220 ft. After the weight increase the takeoff distance is given by:

$$D_{50}(a) = 2220(3200/3000)^2 = 2526 \text{ ft} \quad (12)$$

b. The new best rate-of-climb speed at sea level, standard day, $V_y(a)$, is given by:

$$V_y(a) = 90(3200/3000)^{1/2} = 93.0 \text{ kts} \quad (13)$$

c. Calculating the climb angle at the increased weight can be done by several methods, depending upon the data available from the aircraft operations handbook or flight manual. Where handbook or manual data are not available, data such as climb rate or sink rate may be obtained by performing a limited amount of climb tests. Any such performance tests must be conducted with FAA approval.

Method 1: A general equation for calculating climb performance can be obtained if best rate-of-climb data are available in the aircraft operations handbook for different airplane weights. These data can be used to calculate an effective thrust during takeoff, and the effective ratio of drag to lift. For stable climb conditions at moderate climb angles where the cosine of the climb angle may be assumed to be essentially equal to unity, the sine of the climb angle g, which is also the ratio of rate-of-climb to climb speed, is determined from:

$$\text{Sin}\gamma = R_c/(101.3 \cdot V_y) = F/W - C_d/C_l \quad (14)$$

where F is the thrust developed by the propeller, and C_d/C_l is the ratio of drag to lift coefficients. Thrust is the product of propeller efficiency and engine power, divided by airspeed, with appropriate unit conversions. If it is assumed that the ratio of propeller efficiency to airspeed is approximately constant for airspeeds used for best-rate-of climb, then it can be assumed that thrust remains approximately constant for a given horsepower rating for takeoff. By obtaining

R_c and V_y for two different weights, two simultaneous equations are obtained using equation 14. These may then be solved for F and the ratio of C_d/C_l, since only the ratio is required.

In addition to the data for a weight of 3000 lbs, the manual gives a rate-of-climb of 1140 ft/min at 2700 lbs. The best rate-of-climb speed for a weight of 2700 lbs will be the speed for 3000 lbs times the square root of the ratio of the two weights, or 85.4 kts. Writing two equations with these values, and by subtracting one from the other, the effective thrust, F, is found to be 686 lbs, and the drag/lift coefficient ratio is 0.1222.

Substituting the values for thrust, drag/lift ratio, and airspeed for the desired weight of 3200 lbs yields climb angle of 5.29°. For a climb airspeed of 93.0 kts, the rate-of-climb is obtained as 868 ft/min.

Method 2: Rate of climb, Rc, in ft/min, is:

$$R_c = (33000\eta P)/W - R_S \tag{15}$$

where P is engine horsepower, η is propeller efficiency, W is airplane weight in pounds, and R_s is airplane power off sink rate in ft/min.

Some aircraft operations handbooks give a power off glide ratio and speed, from which a sink rate can be calculated. The sink rate calculated using these values is not the same as is obtained when operating at best rate-of-climb speed and propeller rpm. The best power off glide condition for an airplane with a variable pitch propeller is obtained with the propeller at low rpm (i.e. a blade pitch angle that provides minimum drag, and usually at an airspeed that is higher than that for best rate-ofclimb. Note that in equation (14), if thrust is zero in glide, then the sine of the glide angle is just equal to the ratio of the drag to lift coefficients. For best glide distance this ratio will be lower than the ratio obtained during takeoff climb. For example, for the airplane in Example 1, the aircraft operations handbook states that the airplane will glide 1.7 nautical miles while losing 1000 ft in height, at an airspeed, Vg, of 105 knots. The glide angle, gg, is calculated by observing that its tangent is given by the ratio of the height lost to the distance traveled. Thus:

$$\gamma_g = -\tan^{-1}[1000/(1.7 \times 6076.1)] = -5.53^{\circ} \tag{16}$$

In this mode of operation C_d/C_l is equal to the sine of 5.53°, or 0.0964. In the calculation above, it was found that C_d/C_l was 0.1222 for takeoff with the

propeller operated at maximum rpm.

The rate of sink in takeoff configuration can be obtained by conducting glide tests at the speed for best rate-of-climb with the propeller at high rpm. The time required to lose a fixed altitude, 1000 ft or more, while holding constant airspeed, will give a sink rate that can be used in equation (15). At 90 kts and high rpm, the sink rate for the example airplane is approximately 1125 ft/m.

Propulsive efficiency, that is the product of propeller efficiency and installed power, can be calculated from equation (15) by using this sink rate, in conjunction with the manual value for climb rates at a given weight. Once these factors have been obtained, the climb rate at a different weight can be calculated, and this, coupled with the new climb speed, will allow the climb angle to be computed as in Example 1.

In Example 1 the best rate-of-climb was 970 ft/min at sea level at a weight of 3000 lbs. Substituting these values into equation (15), along with the sink rate of 1125 ft/min, gives a product of propeller efficiency and horsepower, for this airplane, of 190. With no change in horsepower or propeller efficiency, substituting these values in equation (15) gives an equation for rate-of-climb at any weight, W:

$$R_c = (6.285 \times 106/W) - 1125 \text{ ft/m}$$

At a weight of 3200 lbs, the rate-of-climb becomes 839 ft/m. At an airspeed of 93 kts, the climb angle g is given by:

$$\gamma = \sin^{-1}[839/(101.3 \times 93)] = 5.11^{\circ}$$

Method 3: An empirical expression for calculating the rate-of-climb, Rc(2), at one weight, W(2), when the rate-of-climb, $R_c(1)$, at a different weight, W(1), is known is given by:

$$R_c(2) = R_c(1)[W(1)/W(2)]^{1.5} \qquad (17)$$

Substituting 3000 lbs for W(1), 3200 lbs for W(2), and 970 ft/m for $R_c(1)$, $R_c(2)$ is calculated to be 880 ft/m. In turn, climb angle g by this method is given by:

$$\gamma = \sin^{-1}[880/(101.3 \times 93)] = 5.36^{\circ}$$

d. Reference height for the 3200 lbs takeoff weight can now be calculated

with each of the three rate-of-climb values by using the equation:

$$h = 50 + (8200 - D_{50}) \times \tan \gamma$$

From the rate-of-climb of Method 1:

$$h = 50 + (8200 - D_{50}) \times \tan (5.29) = 575 \text{ ft}$$

From the rate-of-climb of Method 2:

$$h = 50 + (8200 - D_{50}) \times \tan (5.11) = 557 \text{ ft}$$

From the rate-of-climb of Method 3:

$$h = 50 + (8200 - D_{50}) \times \tan (5.36) = 582 \text{ ft}$$

The modest discrepancies among the three calculated values are related to the erroneous assumption that the ratio of propeller efficiency to airspeed is essentially constant. To be conservative, the lower value for h may be used in the analysis, or alternatively, the average of the three methods, 571 ft.

Step 2. Calculate reference Mach number.

a. Speed of sound at height h = 571 ft, from equations (3) and (4) is:

$$c = 1114.4 \text{ ft/s at } 571 \text{ ft above sea level}$$

b. Square root of air density ratio at 571 ft is given by equations (5-7):

$$s = 0.97954 / 0.99614 = 0.98334$$

c. Best rate-of-climb speed of 93.0 kts at sea level becomes airspeed at 572 ft of:

$$V_{tas} = 93/0.983341/2 = 93.8 \text{ kts}$$

d. Airplane Mach number at 93.8 kts is:

$$M = (1.688 \times 93.8)/1114.4 = 0.1421$$

e. Propeller rotational Mach number is given by equation (9):

$$M_R = 0.8551$$

f. Helical tip Mach number is given by the square root of the sum of the squares of the airplane and propeller rotational Mach numbers.

$$M_h = [(0.1421)^2 + (0.8551)^2]^{1/2} = 0.8668$$

Step 3. Reference horsepower remains essentially constant.

Step 4. Calculate the increment in noise level under 14 CFR part 36 Appendix G operating conditions

when the airplane is operated at a weight of 3200 lbs instead of at 3000 lbs, without further changes.

a. Increase in noise level due to decrease in height from 690 ft to 571 ft:

$$\Delta_h = 22 \times \log(690/571) = 1.81 \text{ dB}$$

b. Increase in noise level due to increase in helical Mach number:

From Example 1, Mh = 0.8666.

$$\Delta_M = 150 \times \log(0.8668/0.8666) = 0.02 \text{ dB}$$

where the nominal value helical tip Mach number correction of 150 is assumed .

c. Change in noise level due to change in climb angle:

In Example 1 the climb angle was 6.11°. Using the average climb angle obtained from the three methods described above, 5.25°. Tests conducted by FAA under controlled conditions in a wind tunnel show that for typical small propeller airplane, sound levels increase as climb angle increases due to the change in air-inflow angle to the propeller. On average an increase of 0.5 dB per degree increase of inflow angle was observed in the tests Then, the change due to climb angle is given by

$$\Delta_\gamma = 0.5(\gamma_a - \gamma_b) = 0.5(5.25 - 6.11) = -0.43 \text{ dB} \quad (18)$$

d. Total change in noise level:

The total change in noise level, ΔL, is the algebraic sum of the three adjustments.

$$\Delta L = 1.81 + 0.02 - 0.43 = 1.4 \text{ dB}$$

Clearly, a substantial acoustical change is created if the weight for this airplane is increased to 3200 lbs without any other change to the engine/ propeller installation or other operating conditions.

4.2 Change from Fixed to Variable Pitch Propeller

If no other change is made to the airplane, such as increasing horsepower, the primary effect of changing from a fixed to variable pitch propeller of the same diameter is a change in Mach number. Typically, fixed pitch propellers are designed to operate optimally under cruise conditions where the propeller is

designed to reach its maximum continuous rated rpm. During climb at the speed for best rate-of-climb the propeller cannot develop anywhere near its maximum rpm. Typically, takeoff rpm is approximately 85 percent of maximum rpm. For example a 150 hp engine having a maximum propeller rpm of 2700 will develop about 2300 rpm at takeoff. A 235 hp engine with a maximum rated rpm of 2575 typically develops about 2200 rpm in takeoff climb.

One of the primary reasons for changing from a fixed to variable pitch propeller is to shorten takeoff distance and to improve takeoff climb rate. An examination of aircraft operations handbooks for airplanes certified with both fixed and variable pitch propellers, at the same horsepower and takeoff weight, indicates the following nominal characteristics:

a. Takeoff distances to a height of 50 ft with variable pitch propellers are approximately 88-90 percent of the distance required with a fixed pitch propeller.

b. At the same takeoff weight and airspeed, the rate-of-climb with a variable pitch propeller is approximately 9-10 percent greater than with a fixed pitch propeller.

The incremental difference in noise level between an airplane equipped with a variable pitch propeller and a fixed pitch propeller can be estimated by using the same adjustment equations used before for height, Mach number, engine power, and climb angle.

Example 2: The aircraft operations handbook for a representative fixed gear airplane with a takeoff weight of 2900 lbs has the following performance data with fixed and variable pitch propellers:

	Fixed	Variable
Takeoff distance, ft	1510	1350
Rate-of-climb, ft/m	825	900
Climb speed, V_y, kts	87	87
Propeller dia, in	80	80
Propeller rpm in climb	2200	2575

Using the equations provided in Section 4.1 above, the following calculated quantities are obtained:

	Fixed	Variable
Reference height, ft	679	753
Climb angle, degrees	5.37	5.86
Speed of sound, ft/s	1113.9	1113.6
True airspeed, kts	87.9	88.0
Airplane Mach number	0.1332	0.1334
Rotational Mach number	0.6894	0.8072
Helical Mach number	0.7021	0.8181

The difference in engine horsepower developed with the two propellers in climb can be calculated be using equation (15) to write two equations for the rate-of-climb in terms of horsepower and sink rate, since the sink rate is the same and thus the only difference in rate-of-climb in the two situations is the actual propulsive power. For the fixed pitch case:

$$825 = (33000\eta P_f)/2900 - R_s$$

For the variable pitch case:

$$900 = (33000\eta P_v)/2900 - R_s$$

Subtracting the first equation from the second results in a difference of about 7 horsepower. The nominal maximum continuous power for the engine is 235.

All the information necessary to calculate the difference in noise levels between the two propeller installations is now available. In the nomenclature of the adjustment equations given previously, the fixed pitch propeller, the "before" conditions has the subscript "b" and the variable pitch propeller has the subscript "a". The difference in the noise levels for the two cases is the algebraic sum of the following adjustments:

a. Decrease in noise level due to increase in reference height:

$$\Delta_h = 22 \times \log(679/753) = -0.99 \text{ dB}$$

b. Increase in noise level due to increase in helical Mach number:

$$\Delta_M = 150 \times \log(0.8181/0.7021) = 9.96 \text{ dB}$$

c. Increase in noise level due to increase in engine power:

The rated maximum continuous power for the engine is 235 horsepower. If propeller efficiency for the two operating conditions is essentially the same, with an assumed value of 0.8, the incremental change in noise level is approximately:

$$\Delta_P = 17 \times \log[(0.8)(235 + 7)/(0.8)(235)] = 0.22 \text{ dB}$$

d. Increase in noise level due to increase in climb angle:

$$\Delta_\gamma = 0.5 \times (5.86 - 5.37) = 0.25 \text{ dB}$$

e. Total change in noise level:

$$\Delta L = -0.99 + 9.96 + 0.22 + 0.25 = 9.44 \text{ dB}$$

Clearly, an acoustical change exists between the fixed and variable pitch propeller installations unless some other changes are made to the airplane. Note that this case clearly demonstrates a major difference between the older Appendix F test conditions and the current part 36 Appendix G. Under part 36 Appendix F, both planes would be flown at the same altitude, eliminating the height effect of item a. above. Since maximum continuous power in level flight would be used, it would be expected that the fixed pitch propeller would develop maximum rated rpm, the same as for the variable pitch propeller. Since they are of the same diameter, they would have the same helical Mach numbers, and the adjustment of item b above would be equal to zero. Finally, there is no climb angle difference to account for, so item c above would also be equal to zero. Under part 36 Appendix F, the fixed and variable pitch propeller installations would have the same noise level.

4.3 Change in Propeller Diameter

Calculating the effect on Appendix G noise level of changing propeller diameter without any other change in power or performance is a straightforward application of the following equation:

$$\Delta_M = k \times \log(M_a/M_b)$$

where k equals a constant dependent on the propeller design and Mach number range. A nominal value of 150 is permitted in § G36.201 if M_T is smaller than M_R (test and reference respectively).

Although a change in propeller diameter will usually also change performance, if it can be shown that no degradation in takeoff distance or climb performance is created, the airplane performance before the change can be stipulated as the performance after the change. It is clear that an increase in

diameter, considered alone, will increase the noise level. It is sometimes desirable to increase propeller diameter to improve climb performance, sometimes at the sacrifice of some cruise capability. The increased noise level caused by the greater diameter can be offset by a reduction in rpm, if the resulting airplane performance is satisfactory. Where this method is used to show "no acoustical change," it may be necessary to perform takeoff and climb tests to verify performance. The following two examples illustrate the effect that changes in propeller diameter have on the noise level.

Example 3: The airplane in Examples 1 and 2 is normally equipped with a two-blade propeller having an 84-inch diameter. The same propulsive efficiency is claimed when using the same engine, same propeller rpm, if the propeller is replaced with a propeller of 80-inch diameter. For the same reference height and airplane speed, the difference in noise level between the two installations may be calculated as follows. In Examples 1 and 2, the airplane Mach number was 0.1378 and the propeller rotational Mach number was 0.8552 for an 84-inch diameter propeller. For the same altitude and rpm, the rotational Mach number is directly proportional to the propeller diameter, so the rotational Mach number for the 80-inch diameter propeller is 80/84 times 0.8556, or 0.8149. The corresponding helical Mach numbers after the change and before the change become 0.8265 and 0.8666. The noise level difference is:

$$\Delta_M = 150 \times \log(0.8265/0.8666) = -3.09 \text{ dB}$$

If the new propeller has three blades, which would cause a shift in the blade passage frequency, the above analysis would not be adequate to justify "no acoustical change". The analysis would have to be extended to account for the noise delta caused by the ground reflections and A-weighing filter effects, or flyover tests would have to be conducted.

Example 4: An applicant wishes to replace an existing fixed pitch propeller with a diameter of 76 inches for a different pitched propeller with a diameter of 80 inches. The new propeller is designed to provide a somewhat shorter takeoff distance and better rate-of-climb for the airplane. The applicant does not want to go to the trouble of determining the improvement in takeoff distance or climb rate, and is willing to use the existing handbook data to determine reference height.

The applicant has demonstrated to the FAA that, in flight during reference climb conditions, his existing propeller develops 2300 rpm. He believes that,

even with a modest limitation on climb rpm to negate the increase in noise level that a larger diameter propeller would normally generate, the larger propeller will still be advantageous. The rpm limitation that would have to be imposed for "no acoustical change" to result, assuming the reference height of 700 ft and true airspeed of 74 kts do not change, is determined as follows.

Since the airplane climb speed remains the same, the helical Mach number will be the same if the rotational Mach numbers for the two propellers are held constant. The actual reference height and airspeeds are not relevant to this determination. It is not even necessary to calculate the actual Mach numbers, since the rotational Mach numbers will be the same if the products of propeller diameter and rpm remain constant for the two cases. For the original 76-inch propeller, the product is 76 times 2300 or 174,800. The rpm limitation with an 80-inch propeller is therefore 174,800 divided by 80, or 2185 rpm. If this rpm gives satisfactory takeoff and climb performance, limiting climb rpm to 2185 will result in no acoustical change when the larger propeller is installed.

4.4 Change in Engine Power

Increasing the size of an engine without changing the takeoff weight of an airplane will change the Appendix G noise level. If no change in performance were involved, the level would increase by 17 times the logarithm of the ratio of the increased horsepower to the original horsepower. However, clearly a change in performance does take place. Takeoff distance is shortened, and climb rate is increased. Often, but not always, a propeller change is also made. If the increase in performance offsets the effect on noise level of the change in engine horsepower, no acoustical change occurs. The following example illustrates the required analysis.

Example 5: The airplane in Example 1 is originally equipped with an engine rated at 225 horsepower at 2600 rpm. The desired installation is for an engine rated at 250 horsepower at 2650 rpm. The same 84 inch two-blade propeller is used in each case. The acoustical effect of this change is evaluated as follows.

Step 1. If propeller efficiency remains the same, takeoff distance varies inversely with engine power and directly as the square of takeoff weight. The takeoff distance to 50 ft height after the increase in horsepower, $D_{50}(a)$, without any weight increase, is the original takeoff distance, $D_{50}(b)$, times the ratio of the original horsepower to the increased horsepower:

$$D_{50}(a) = D_{50}(b) \times P(b)/P(a) \text{ ft}$$

In this example:

$$D_{50}(a) = 2220(225)/(250) = 1998 \text{ ft}$$

Step 2. From equation (15), rate-of-climb for a given airplane configuration is directly proportional to the ratio of engine power to airplane weight, minus the power off sink rate. The constant of proportionality is the unit conversion factor of 33,000 times the propeller efficiency. In Example 1, the product of propeller horsepower developed in climb is less than the rated horsepower due to installation effects and air density less than at sea level. It can be assumed that the same ratio of losses will apply to a slightly higher rated horsepower engine. Assuming these losses cancel each other out, the apparent propeller efficiency for Example 1 can be stated as the propulsive efficiency, 190, divided by the rated horsepower, 225, for an apparent efficiency of 0.844. Equation (15) can then be used to determine the rate-of-climb at the increased horsepower:

$$R_c(a) = (33000)(0.844)(250)/3000 – 1125 = 1197 \text{ ft/m}$$

Step 3. Climb angle is given by:

$$\gamma = \sin^{-1}[R_c/(1.688 \times 60 \times V_y)]$$

$$\gamma_a = \sin^{-1}[1197/(101.3)(90)] = 7.55^o$$

Step 4. The reference height after the change, Ha, is:

$$H_a = 50 + (8200 - 1998) \tan(7.55) = 872 \text{ ft}$$

Step 5. Determine reference helical Mach number:

a. At 871 ft the speed of sound is:

$$c = 1113.2 \text{ ft/s}$$

True airspeed is calibrated airspeed divided by the square root of the density ratio:

$$s = 0.97472$$

b. Best rate-of-climb speed of 90 kts at sea level becomes a true airspeed at 871 ft of:

$$V_{tas} = 90/0.974721/2 = 91.2 \text{ kts}$$

c. Airplane Mach number at 91.2 kts is:

$$M = (1.688 \times 91.2)/1113.2 = 0.1383$$

d. Propeller rotational Mach number is:

$$M_R = 0.8725$$

e. Helical tip Mach number is:

$$M_h = [(0.1383)^2 + (0.8725)^2]^{1/2} = 0.8834$$

Step 6. Reference horsepower is now 250.

Step 7. Calculate the increment in noise level under 14 CFR part 36 Appendix G operating conditions:

a. Change in noise level due to increase in height:

From Example 1, $H_b = 690$ ft, and from above $H_a = 872$ ft.

$$\Delta_h = 22 \times \log(690/872) = -2.24 \text{ dB}$$

b. Increase in noise level due to increase in helical Mach number:

From Example 2, $M_h = 0.8666$:

$$\Delta_M = 150 \times \log(0.8834/0.8666) = 1.25 \text{ dB}$$

c. Increase in noise level due to increase in horsepower:

$$\Delta_P = 17 \times \log(250/225) = 0.78 \text{ dB}$$

d. Change in noise level due to change in climb angle:

In Example 1 the climb angle was 6.11 degrees. From equation (18):

$$\Delta_\gamma = 0.5 \times (7.55 - 6.11) = 0.72 \text{ dB}$$

e. Total change in noise level:

The total change in noise level, ΔL, is the algebraic sum of the four adjustments.

$$\Delta L = -2.24 + 1.25 + 0.78 + 0.72 = 0.51 \text{ dB}$$

The change in noise level due to an increase in horsepower, in this example, is not offset by the effect of improved takeoff performance, resulting in an

"acoustical change" of 0.5 decibel. In order to become a "no acoustical change" situation, some change in rating should take place. A small reduction in allowable takeoff rpm might be reasonable. Several iterations of the above calculations might be necessary to determine the optimum conditions.

4.5 Increase in Drag with No Other Changes

Any modification to an airplane that increases its drag during takeoff and initial climb will increase the Appendix G noise level unless other changes are also introduced. If takeoff distance is increased, or rate-of-climb decreased, or both, the reference height will decrease. The change in level can be calculated from the adjustment equations provided previously if the change in performance can be determined. If an applicant wants to show compliance with the noise regulation via the "no acoustical change" method, he will probably have to conduct takeoff distance and climb tests. If it looks as though the proposed modification will increase drag sufficiently to make a measurable performance change, then an offsetting change will be required. The amounts of increase or decrease in noise level involved can be calculated by the methods use in the previous examples.

4.6 Acoustical Effects of Combined Changes

Many proposed airplane modifications involve several changes. Examples are replacing an engine and fixed pitch propeller with a higher power engine and a variable pitch propeller, or increasing engine power and takeoff weight at the same time. The acoustical consequences of these combined effects can be calculated by combining the methods used in the examples. The sequence for calculating these effects is as follows:

a. Determine the effect changes in takeoff distance and rate-of-climb will have on reference height.

b. Determine the effect of helical Mach number caused by any changes in airplane speed, propeller rotational speed, or change in speed of sound because of change in reference height.

c. Determine the effect of any changes in engine power.

d. Determine any change in noise level due to change in airplane climb angle.

e. Obtain the algebraic sum of the four incremental changes in sound level.

f. If the sum is greater than zero, there are two choices:

Conduct Appendix G tests as described in the regulation; or,

Evaluate different operating conditions to obtain an incremental noise level that is not greater than that of the original airplane. This may be accomplished by derating the engine, reducing fuel/payload, and/or limiting maximum takeoff rpm. One or a combination of these modifications may be iterated until a negative noise increment is obtained by the methods used in the examples. The cost of not performing an Appendix G noise test should be balanced against the loss of airplane performance or takeoff weight limitations during the lifetime of operation.