U.S. Department
of Transportation

Federal Aviation Administration

Advisory Circular

Subject:

NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION

Date: 7/15/03
Initiated by: AEE-100

AC No: 36-4C
Change:

1. PURPOSE.

a. Contents: This advisory circular (AC) contains information concerning the aircraft noise certification requirements of part 36 of the United States Code of Federal Regulations (CFR) Title 14. 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, FAA 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 FAA 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. The regulation that this AC references to is part 36, as amended through August 7, 2002 (Amendment 36-24).

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 FAA 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 FAA 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 FAA 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.

The FAA Office of Environment and Energy (AEE) (located in Washington DC) has approved a substantial number of equivalent procedures proposed by applicants. Many of these equivalent procedures are referred to in this document because, through their extensive usage by applicants, 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 FAA for aircraft noise certification applications. The acceptability of an equivalent procedure for an aircraft noise certification application is subject to FAA review and approval on a project by project basis.

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

Paragraph Number: new easy to reference number for each section of 14 CFR part 36 that is addressed

1. **Citation Number: Regulatory section of** 14 CFR part 36 that is being addressed

2. 286. Section B36.7(b)(6).

Actual regulatory text (*italicized, bold and indented*) reproduced for better readability

> ***The weight of the airplane at the brake release must be the maximum takeoff weight at which the noise certification is requested….***

a. Explanation

Brief "Plain English" explanation of regulatory text (*appears only if text is not self explanatory*)

> This section specifies criteria for defining a reference maximum takeoff weight of an airplane.

b. Supplemental Information

Supplemental information *(included only if necessary)*.

> (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 operating limitations in the limitations section of the airplane flight manual.

c. Procedures:

Additional procedure-related information *(included only if necessary)*.

> (1) Applicant's Responsibility: An applicant must define and obtain FAA approval of an airplane maximum takeoff weight to calculate reference EPNL values.

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. Part 36, Subpart D and other related sections of part 36, address supersonic airplane noise certification requirements only for the Concorde airplane and there currently are no identified procedures for future supersonic planes. An applicant must contact the FAA Office of Environment and Energy for assistance and future plans associated with the noise certification of 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 December 22, 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 United States of America, such as is identified in part 91. An applicant or operator may review the current operational limitations that are found in the Operating Noise Limits of part 91, Subpart I, section 91.801.

e. 14 CFR part 36 History: The table below summarizes the date of adoption of part 36 and all amendments that followed.

Amendment #, Effective Date	Title	Subject
00-0, 12/01/69	Adoption of part 36	Adds new part 36 to the FAR and makes procedural changes to part 21.
36-1, 12/01/69	Approach Noise Test Conditions	Changes the type certification approach noise test conditions for subsonic transport category airplanes and for subsonic turbojet airplanes regardless of category; to ensure that the test is conducted with the same configuration as that used during the airworthiness type certification, and does not result in noise levels less than those that will be generated in normal operation.
36-2, 12/01/73	Noise Standards for Newly Produced Airplanes of Older Type Designs	Requires certain new production turbojet and transport category airplanes to comply with part 36, regardless of type certification date as a condition for issuance of certain standard airworthiness certificates.
36-3, 01/20/75	Acoustical Change Approvals	Tightens the conditions under which an applicant must show that issuance of type certificate changes will not increase take-off and sideline noise levels.
36-4, 02/07/75	Noise Standards for Propeller Driven Small Airplanes	Prescribes noise standards for normal, utility, acrobatic, transport, and restricted category type certificates for propeller driven small airplanes; issuance of standard airworthiness certificates and restricted category airworthiness certificates for newly produced propeller driven small airplanes of older type designs; prohibits acoustical changes in the type designs that increase noise levels beyond specified limits.
36-5, 09/20/76	Noise Type Certification and Acoustical Change Approvals	Changes the procedures for measuring and evaluating the noise of subsonic transport category airplanes and turbojet engine powered airplanes; governs new type certificates and acoustical change approvals for which application, is made after September 17, 1971.
36-6, 01/24/77	Noise Regulations for Propeller Driven Small Airplanes Submitted to the FAA by the EPA; and Notice of Decision	Changes procedures to increase the numbers of test flights, modify performance correction formula, and revise noise test engine power; decision not to make other certain EPA recommended amendments.
36-7, 10/01/77	Noise Level Limits and Acoustical Change	Provides for three stages of aircraft noise levels with specified limits, with definitions of classification of airplanes under each stage; applications after November 5, 1975 to be Stage 3;

Amendment #, Effective Date	Title	Subject
	Requirements for Subsonic Transport Category Large Airplanes and for Subsonic Turbojet Powered Airplanes	prescribes acoustical change requirements for airplanes in each stage.
36-8, 04/03/78	Noise Limits and Acoustical Change Requirements for Subsonic Transport Category Large Airplanes and Turbojet Powered Airplanes	Amends noise limits for new airplane designs; limits noise levels of certain older airplane types if designs are changed; amends noise measuring points and noise test conditions; this amendment complements 36-7 and includes minor modifications to the Stage 3 noise limits, and also brings part 36 into greater conformity with ICAO standard.
36-9, 04/03/78	Aircraft Noise Measurement and Evaluation Specification	Updates and clarifies the procedures and standards for conducting certain aircraft noise certification tests, based on developments in the state of the art and on aircraft noise test experience; achieves substantial conformity with modifications to ICAO Annex 16.
36-10, 07/31/78	Civil Supersonic Airplanes Noise and Sonic Boom Requirements	Prescribes final rules for SSTs except Concordes with flight time before January 1, 1980; prohibits issuance of standard airworthiness certificates to Concordes that do not have flight time before January 1, 1980 and that do not comply with part 36; also amends part 21 and part 91 concerning operations of subject airplanes; FAA goal to not certificate or permit to operate any future design SST that does not meet standards then applicable to subsonic airplanes.
36-8, 09/28/78 CORRECTION	(Title): Correction to Minimum Thrust Cutback Altitudes	Prescribes the minimum altitude at which thrust may be reduced during take-off noise tests for certain airplanes powered by turbojet engines with high bypass ratios, which were previously certificated under the stage 2 limits; affects approvals for voluntary changes in type design which might increase the noise levels and is necessary to avoid an unintended effect of Amendment 36-8.
36-9, 01/15/79 CORRECTION	(Title): PNLT Corrections Formula for Ambient Atmosphere Conditions Affecting the Sideline Flight Path	Executes FAA's intended statement of the rule and prescribes an appropriate correction to the measured noise data when atmospheric conditions do not conform to the prescribed standard reference conditions.
36-11, 11/10/80	Operating Limitations and Related Requirements for Certain Propeller Driven Small Airplanes	Provides for certain exclusions from the rule; applies to operation of newly produced airplanes (without flight time before January 1, 1980), and acoustically changed airplanes (without flight time in the changed design before January 1, 1980), that have not been shown to comply with part 36 noise levels; requires that an operating limitation be appropriately provided to the pilot.

Amendment #, Effective Date	Title	Subject
	Designed for Agricultural Aircraft Operations or Fire Fighting Purposes	
36-12, 08/01/81	Noise Levels for Turbojet Engine Powered Airplanes and for Large Propeller Driven Airplanes: Recommended Regulations Submitted to the FAA by the EPA	Adds provision for FAA approval or equivalent procedures; clarifies and simplifies rule language to better explain which noise level requirements apply and which “tradeoff” provisions are available to applicants for approval of modifications to certain, already certificated aircraft type designs; FAA decisions not to prescribe other EPA recommended amendments.
36-13, 02/17/87	Airworthiness Standards and Operating Rules: Commuter Category Airplanes	Amends parts 21, 23, 36, 91, and 135 concerning an additional category of propeller driven, multi engine airplane designated as Commuter Category.
36-14, 2/05/88	Noise Standards for Helicopters in the Normal, Transport and Restricted Categories	Adds noise certification Standards applicable to helicopters; applies to civil helicopters in the normal, transport and restricted categories and provides noise level limits and test procedures for the issuance of original and amended type certificates; prohibits changes in type design of helicopters that may increase noise levels beyond certain limits; does not limit further manufacture of existing helicopter types; provides commonality with ICAO Annex 16.
36-15, 05/06/88	Standards Governing the Noise Certification of Aircraft	Revises certain provisions of the regulations to make them more understandable and easier to use; simplifies noise certification test and record keeping requirements.
36-16, 12/22/88	Noise Certification Standards for Propeller Driven Small Airplanes	Revises noise certification standard by substituting the use of actual take-off tests for the level flyover tests; revises the noise level limit numbers to approximate the sound levels measured in accordance with Appendix F of part 36; exempts both antique airplanes and airplanes modified by the addition of floats and skis from the acoustical change measurement and documentation requirements of part 21.
36-17, 08/14/89	Noise Standards; Limits on the Growth of Noise from Certain Airplanes and Airplane Types	Requires that aircraft certificated within certain stages remain within those stages; applies to large transport category aircraft and to turbojet powered aircraft regardless of category and prohibits modification of individual airplanes and whole airplane types which result in increased noise beyond the limits of an airplane's certificated stage; does not restrict changes that result in decreased noise but does prohibit any remodification of an airplane which would return it to its original noise level.
36-18, 08/18/90	Revision of General Operating and Flight Rules	Reorganizes and realigns the rules to make them more understandable and easier to use; provides more flexibility for certain operations.
36-19, 12/31/92	Primary Category	Establishes a new primary category of aircraft and new simplified procedures for type, production, and airworthiness certification, and

Amendment #, Effective Date	Title	Subject
		associated maintenance procedures; maximum certificated weight of no more than 2,700 pounds, a maximum seating capacity of four, and unpressurized cabins.
36-20, 09/11/92	Alternative Noise Certification for Primary, Normal, Transport and Restricted Category Helicopters not Exceeding 6,000 Pounds Maximum Take-off Weight	Adds Appendix J to part 36 providing for an alternative noise certification procedure; new appendix is an optional alternative to the existing helicopter noise requirements and is not an additional regulatory requirement; applicants may demonstrate compliance with either Appendix H or the less costly, but more stringent Appendix J.
36-21, 12/29/95	Authority Citation	Revises part 36 authority citation.
36-22, 12/13/99	Noise Certification Standards for Propeller-Driven Small Airplanes	Harmonizes the U.S. noise certification regulations and the European Joint Aviation Requirements (JAR) for propeller-driven small airplanes. The international standards and practices, as issued under International Civil Aviation Organization (ICAO) Annex 16, Volume 1, and its associated Technical Manual are the harmonization basis.
36-23, 3/1/2002	Removal of Expired Special Federal Aviation Regulations	Removes Special Federal Aviation Regulation (SFAR) Number 41 editorial note from part 36.
36-24, 8/7/2002	Noise Certification Standards for Subsonic Jet Airplanes and Subsonic Transport Category Large Airplanes	Harmonizes the U.S. noise certification regulations and the European Joint Aviation Requirements (JAR) for subsonic jet airplanes and subsonic transport category large airplanes. The international standards and practices, as issued under International Civil Aviation Organization (ICAO) Annex 16, Volume 1 (Chapter 3), Amendment 7, and its associated Technical Manual are the harmonization basis.

2. CANCELLATION.

Advisory Circular 36-4B, Noise Certification Handbook, dated March 23, 1988, is canceled.

3. REFERENCES.

The following references identify FAA Orders, Advisory Circulars, and Reports that provide direction and/or guidance on acceptable processes and procedures for aircraft noise certification. References to current ICAO and JAA noise standards are also listed. As these documents are referenced in this AC, information is also provided as to the extent that their provisions apply to a given type of aircraft noise certification process. Applicants are encouraged to contact FAA AEE to determine if more recent editions are available and applicable to noise certification actions that are being considered for FAA approval.

(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 the Use 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 or organizational designations that depict FAA and Applicant roles 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: The Federal Aviation Administrator or any person to whom he has delegated his authority in the matter concerned. (Ref: part 1)

(2) Aircraft Certification Office (ACO): The (FAA) office that administers the type certificate and production approval of products in the area where the manufacturer is located (Ref: FAA AC 21-6A, dated 7/1/82)

(3) Applicant: 14 CFR part 21.13, states: "Any interested person may apply for a type certificate". The person that applies to the FAA for an aircraft type certificate, whether a new (original), amended, supplemental or provisional type certificate, is identified as the "applicant" and is the entity that must comply with the procedural, certification and production requirements of 14 CFR part 21.

(4) Noise Certification Specialist (NCS): The Directorate (Transport, Small Airplane, or Helicopter) Noise Certification Specialist

(5) Person: An individual, firm, partnership, corporation, company, association, joint-stock association, or government entity. It includes a trustee, receiver, assignee, or similar representative of any of them. (Ref: part 1)

(6) Type Inspection Authorization (TIA): The TIA is the official FAA document that provides direction and communication between the local ACO engineering group and the FAA 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 ACO to be observed during the conduct of the flight or ground testing.

b. Definitions Related to Aircraft

(1) 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 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 14 CFR part 23.

(2) Aircraft: A device that is used or intended to be used for flight in the air. (Ref: part 1)

(3) 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. (Ref: part 1)

(4) 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. (Ref: part 1)

(5) 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. (Ref: part 1)

(6) Civil Aircraft: Aircraft other than a public aircraft. (Ref: part 1)

(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 19,000 pounds or less, intended for non-acrobatic operations. Commuter category airplanes are required to show compliance with part 23.

(8) Helicopter: A rotorcraft that, for its horizontal motion, depends principally on its engine-driven rotors. (Ref: part 1)

(9) Large Aircraft: Large aircraft means aircraft of more than 12,500 pounds, maximum certificated takeoff weight (Ref: part 1)

(10) 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 12,500 pounds or less, and intended for nonacrobatic operation. Normal category airplanes are required to show compliance with 14 CFR part 23.

(11) Normal Category Rotorcraft: A normal category rotorcraft is a rotorcraft with a maximum weight of 7,000 pounds or less and that meets the regulatory requirements of part 27.

(12) 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 61-knot or less stall speed, or is a rotorcraft with a 6-pound per square foot main rotor disc loading limitations, and (ii) weighs not more than 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 part 21, section 21.24.

(13) 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. (Ref: part 1).

(14) Public Aircraft: Aircraft used only in the service of a government, or a political subdivision. It does not include any government-owned aircraft engaged in carrying persons or property for commercial purposes. (Ref: part 1)

(15) Restricted Aircraft: Used for special purpose operations as defined in part 21, section 21.25

(16) Rotorcraft: A heavier-than-air aircraft that depends principally for its support in flight on the lift generated by one or more rotors (Ref: 14 CFR part 1).

(17) Small Aircraft: Small aircraft means aircraft of 12,500 pounds or less, maximum certificated take-off weight. (Ref: part 1)

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

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

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

(23) 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 12,500 pounds or less, and intended for limited acrobatic operation. Utility category airplanes are required to show compliance with part 23.

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	= FAA Advisory Circular
A/C	= Air-conditioning (Environmental Control System)
ACO	= Local FAA Aircraft Certification Office
AEE	= FAA Office of Environment and Energy
AFM	= Airplane Flight Manual
ANM	= FAA Northwest Mountain Region
APU	= Auxiliary Power Unit
ARP	= Aerospace Recommended Practice
CDI	= Course Deviation Indicator
CG	= Center of Gravity
CFR	= Code of Federal Regulations
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, feet
MTOGW = Maximum Take-off Gross Weight
N1 = 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
VNTSC = Volpe National Transportation System Center (DOT)
V_{REF} = Reference Landing Speed

6. - 7. RESERVED.

for Carl E. Burleson
Director of Environment and Energy

TABLE OF CONTENTS

APPENDICES

FIGURES

(Note: The figures identified in the above list were developed for AC 36-4C. Figures contained within part 36 itself have not been included in this list.)

TABLES

(Note: The tables identified in the above list were developed for AC 36-4C. Tables contained within part 36 itself have not been included in this list.)

I. CERTIFICATION PROCEDURES FOR PRODUCT AND PARTS 14 CFR PART 21

8. PART 21 - GENERAL

As part of the overall aircraft certification requirements identified in part 21, applicants must comply with the noise certification requirements of part 36. An applicant for a type certificate must show that the aircraft meets the applicable requirements of part 36 (part 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 (part 21, sections 21.21 & 21.25). Similar requirements are imposed for aircraft manufactured in a foreign country for import into the United States (part 21, section 21.29). Refer to the part 21 regulations for specific regulatory language.

a. Explanation

None

b. Supplemental Information

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

i. Part 23 for normal, utility, acrobatic, and commuter category airplanes,

ii. Part 25 for transport category airplanes,

iii. Part 27 for normal category rotorcraft,

iv. Part 29 for transport category rotorcraft,

v. Part 33 for aircraft engines,

vi. Part 35 for propellers,

vii. Primary category aircraft, and

viii. JAR-VLA aircraft.

(2) Changes in Type Design. Part 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 part 21, section 21.93(a). See paragraph 16 of this AC for further discussion of acoustical change.

9.-11. [RESERVED]

II. NOISE STANDARDS: AIRCRAFT TYPE AND AIRWORTHINESS CERTIFICATION 14 CFR PART 36

12. PART 36 – SUBPART A-GENERAL

a. Explanation

This Subpart specifies the Applicability of part 36, Definitions of Terms Unique to part 36, part 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)

This part prescribes noise standards for the issue of the following certificates:

(1) Type certificates, and changes to those certificates, and standard airworthiness certificates, for subsonic transport category large airplanes and for subsonic jet airplanes regardless of category.
(2) Type certificates and changes to those certificates, standard airworthiness certificates, and restricted category airworthiness certificates, for propeller-driven, small airplanes, and for propeller-driven, commuter category airplanes except those airplanes that are designed for "agricultural aircraft operations" (as defined in § 137.3 of this chapter, as effective on January 1, 1966) or for dispersing fire fighting materials to which § 36.1583 of this part does not apply.
(3) A type certificate and changes to that certificate, and standard airworthiness certificates, for Concorde airplanes.
(4) Type certificates, and changes to those certificates, for helicopters except those helicopters that are designated exclusively for "agricultural aircraft operations" (as defined in § 137.3 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).

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
Airplane
Helicopter
Airplane Categories (See Note A)
- Acrobatic
- Commuter
- Normal
- Primary
- Restricted (See Note B)
- Transport
- Utility
Helicopter Categories
- Normal
- Transport

Large Aircraft
Small Aircraft
Propeller
Jet Airplane
Turboprop Airplane (See Note C)

Notes:

(A) Airplane Categories and Aircraft Classes: 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; propeller-driven 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 under part 21 of this chapter 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 this chapter.

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 FAA 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 under 14CFR part 21 of this chapter for approval of an acoustical change described in § 21.93(b) of this chapter 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 this chapter.

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: Part 21, section 21.93(b) defines an aircraft "acoustical change" and specific aircraft configurations excepted from part 36 requirements. The text of 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 FAA 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 FAA approved method) or 0.30 EPNdB/dB (A) if an applicant has obtained an FAA 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 FAA 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. FAA 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. FAA policy (See Federal Register Vol. 64, No. 225, Page 65655, dated November 23, 1999) permits the 90 day period allowed by part 21, section 21.93(b)(2)(iii) to continue to be used after December 31, 1999, but only for maintenance-related purposes. It cannot be used for meeting Stage 3 requirements due to lack of an adequate number of spare engines or nacelles, or insufficient number of engines or nacelles to operate a Stage 3 fleet at a given time. 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 FAA for the modified aircraft must be documented in an FAA 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 FAA 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: FAA 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)

Each person who applies for the original issue of a standard airworthiness certificate for a subsonic transport category large airplane or for a jet airplane under14CFR part 21 § 21.183 must, regardless of date of application, show compliance with the following provisions of this part (including Appendix B):

(1) The provisions of this part in effect on December 1, 1969, for subsonic airplanes that have not had any flight time before--
(I) December 1, 1973, for airplanes with maximum weights greater than 75,000 pounds, except for airplanes that are powered by Pratt & Whitney Turbo Wasp JT3D series engines;
(ii) December 31, 1974, for airplanes with maximum weights greater than 75,000 pounds and that are powered by Pratt & Whitney Turbo Wasp JT3D series engines; and
(iii) December 31, 1974, for airplanes with maximum weights of 75,000 pounds and less.
(2) The provisions of this part in effect on October 13, 1977, including the stage 2 noise limits, for Concorde airplanes that have not had flight time before January 1, 1980.

a. Explanation

None

b. Supplemental Information

(1) Requirements for Issuance of Airworthiness Certificates: An airworthiness certificate is issued for each airplane produced, and is a means of distinguishing (by date of issuance) airplanes within a production run that comply with the noise certification requirements of part 36. Prior to the original issuance of a standard airworthiness certificate (see part 21, section 21.183) and regardless of the date of application for certification, compliance with the regulatory requirements of part 36 (including Appendix B) is required for a transport category large airplane, or for a jet airplane regardless of category (see paragraph 6-3(k)(1) of reference 7 of this AC). The following Table summarizes the requirements of section 36.1(d).

Maximum Airplane Weights	Airplane Types	Engine Configuration	Effective Date of part36	Compliance Date for Airplanes With Initial Flight Time on or After
75,000 pounds or less	Subsonic	All engines	December 1, 1969	December 31, 1974
Greater than 75,000	Subsonic	Without Pratt & Whitney JT3D engines	December 1, 1969	December 1, 1973
Greater than 75,000	Subsonic	With Pratt & Whitney JT3D engines	December 1, 1969	December 31, 1974
Concorde – all weights	Supersonic	All engines	October 13, 1977	January 1, 1980

(2) "Grandfathered" Airplanes: Airplane types not identified above are "grandfathered" airplanes and are permitted to continue normal operations without showing compliance with the requirements of part 36. For example, the twin-engine propeller-driven Convair 580 or Douglas DC-3 airplanes that first logged flight time before December 31, 1974, did not have to comply with the noise provisions of part 36 and may have received a standard airworthiness certificate under the provisions of part 21, section 21.183, or may have received a standard airworthiness certificate under the provisions of the regulations in effect at the time of certification without compliance with part 36.

c. Procedures:

None.

18. Section 36.1(e)

Each person who applies for the original issue of a standard airworthiness certificate under part 21, § 21.183, or for the original issue of a restricted category airworthiness certificate under 1 part 21, § 21.185, for propeller-driven, commuter category airplanes for a propeller-driven small airplane that has not had any flight time before January 1, 1980, must show compliance with the applicable provisions of this part.

a. Explanation

None

b. Supplemental Information

(1) Requirements for Issuance of Airworthiness Certificates: An applicant must show compliance of individual airplanes with the requirements of part 36 prior to issuance of airworthiness certificates, as prescribed in part 21, section 21.183 or 21.185 (see paragraph 6-3(k)(2) of reference 7 of this AC).

(2) Commuter Category Airplanes: Since airworthiness standards for commuter category airplanes became effective February 17, 1987, (under part 21, Amendment 21-59) there are no airplanes in this category with initial flight time before January 1, 1980. All commuter category airplanes are thus required to show compliance with the noise certification requirements of part 36.

c. Procedures

None.

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, Mom 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.

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.

a. Explanation

None

b. Supplemental Information

(1) The Stage 1 noise limits apply to all helicopters for which application for a type certificate or a change in type design was made prior to March 6, 1986.

(2) The Stage 2 noise levels apply to all helicopters for which application for a type certificate or a change in type design is made on or after March 6, 1986, with the following exception. For helicopters for which application for issuance of an original type certificate in the normal, transport or restricted category is made on or after March 6, 1986, and which the FAA finds to be the first civil version of a helicopter which was designed and constructed for, and accepted for operational use by an Armed Force of the U.S. or the U.S. Coast Guard on or before March 6, 1986, it must be shown that the noise levels of the helicopter certificated under the provisions of Appendix H are no greater than Stage 2 levels plus 2 EPNdB at each measuring point. There is no

corresponding provision under Appendix J. The tradeoff provision of H36.305(b) may not be used to show compliance with Stage 2 levels plus 2 EPNdB, nor may they be used to increase any noise level beyond these limits. Subsequent civil versions (acoustic changes) must meet the Stage 2 requirements without the extra 2 EPNdB at each measuring point. The tradeoff provisions of H36.305(b) may be used in showing stage 2 compliance for these subsequent versions.

(3) Helicopters Excepted: Helicopters that are designated exclusively for agricultural aircraft operations, as defined in part 137, section 137.3, for dispensing fire fighting materials, or for carrying external loads, as defined in part 133, section 133.1(b) are excluded from the noise certification requirements.

(4) 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) Section 21.17 of this chapter notwithstanding, 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) Section 21.101(a) of this chapter notwithstanding, each person who applies for an acoustical change to a type design specified in § 21.93(b) of this chapter 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 filing of the application for a type certificate or change to a type design, the election:

(1) must be approved by the FAA;

(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 FAA.

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 FAA 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 FAA 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 FAA 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 FAA 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

Pursuant to 49 U.S.C. 1431(b)(4), 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. No determination is made, under this part, 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 requires compliance with U.S. Government noise standards for aircraft type and airworthiness certification but does not include 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. Public Law 103-272 (reference 2 of this AC), mandates that the Administrator of the FAA prescribe standards to measure and evaluate aircraft noise. Under this law, an original type certificate may be issued for an aircraft for which substantial noise abatement can be achieved only after the FAA Administrator prescribes standards and regulations that apply to that aircraft. Consideration must be given to relevant information on aircraft noise, consultations with appropriate US and State 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 that are not set forth in full text in the rule. Those standards and procedures are contained in published material which is reasonably available to the class of persons affected and has been approved for incorporation by reference by the Director of the Federal Register under 5 U.S.C. 552 (a) and 1 CFR Part 51.

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 made a part of part 36 of this chapter with the approval of the Director of the Federal Register. (2) Incorporated matter which is subject to subsequent change is incorporated by reference according to the specific reference and to the identification statement. Adoption of any subsequent change in incorporated matter is made under part 11 of this chapter and 1 CFR part 51.

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", first edition, dated 1995

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

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

(x) IEC Publication 60942, entitled "Electroacoustics- Sound Calibrators", second edition, 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 1975.

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 FAA. An applicant should also contact an ACO Specialist prior to submittal of a noise compliance demonstration plan to FAA to determine whether there are new standards and procedures that are applicable to his particular aircraft noise certification process.

c. Procedures

None

29. Section 36.6(d)

Availability for purchase. Published material incorporated by reference in this part may be purchased at the price established by the publisher or distributor at the following mailing addresses:

(1) IEC publications,

(i) International Electrotechnical Commission,3, rue de Varembe, Case postale 131, 1211 Geneva 20, Switzerland

(ii) American National Standard Institute, 11 West 42nd Street, New York City, New York 10036 (Electronic mail address: INFO@ANSI.org).
(2) SAE publications. Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrentown, Pennsylvania 15096.(Electronic mail address: SAE@SAE.org)

a. Explanation

None

b. Supplemental Information

(1) Addresses of Other Organizations: Addresses for other organizations that produce technical standards, references and publications that relate to aircraft noise certification are as follows:

(i) Bureau International de Métrologie Légale
11, rue Turgot
75009 Paris, France

(ii) Engineering Science Data Unit International, Ltd.
251-259 Regent Street
London, England
W1R 7AD, United Kingdom

(iii) International Civil Aviation Organization
999 University Street
Montreal, Quebec
Canada H3C 5H7
(Electronic mail address: Sales_unit@ICAO.org)

(iv) National Institute of Standards and Technology
Building 101, Room A903
Gaithersburg, Maryland 20899
(Electronic mail address: Inquiries@NIST.gov)

c. Procedures

None

30. Section 36.6(e)

Availability for inspection. A copy of each publication incorporated by reference in this part is available for public inspection at the following locations:

(1) FAA Office of the Chief Counsel, Rules Docket, Room 916, Federal Aviation Administration Headquarters Building, 800 Independence Avenue, SW., Washington, D.C.
(2) Department of Transportation, Branch Library, Room 930, Federal Aviation Administration Headquarters Building, 800 Independence Avenue, SW., Washington, D.C.
(3) The respective Region Headquarters of the Federal Aviation Administration as follows:
(i) New England Region Headquarters, 12 New England Executive Park, Burlington, Massachusetts 01803.
(ii) Eastern Region Headquarters, Federal Building, John F. Kennedy (JFK) International Airport, Jamaica, New York 11430.
(iii) Southern Region Headquarters, 1701 Columbia Avenue, College Park, Georgia, 30337.

(iv) Great Lakes Region Headquarters, O'Hare Lake Office Center, 2300 East Devon Avenue, Des Plaines, Illinois 60018.
(v) Central Region Headquarters, Federal Building, 601 East 12th Street, Kansas City Missouri 64106.
(vi) Southwest Region Headquarters,2601 Meacham Boulevard, Fort Worth, Texas 76137-4298.
(vii) Northwest Mountain Region Headquarters 1601 Lind Avenue, Southwest, Renton, Washington 98055.
(viii) Western-Pacific Region Headquarters 15000 Aviation Boulevard, Hawthorne, California 92007.
(ix) Alaskan Region Headquarters, 222 West 7th Avenue, # 14, Anchorage, Alaska 99513.
(x) European Office Headquarters, 15, Rue de la Loi (3rd Floor), B-1040 Brussels, Belgium.

a. Explanation

None

b. Supplemental Information

(1) Other DOT/FAA Addresses: Current addresses of U.S. Department of Transportation and FAA organizations (and Specialists) that might provide assistance to an applicant are as follows:

(2) FAA/DOT Offices, Washington, D.C.:

(i) FAA Office of Environment and Energy (AEE-1) Federal Aviation Administration
Headquarters Building, Room 900W,
800 Independence Avenue, SW.
Washington D.C. 20591

(ii) FAA Office of the Chief Council (AGC-1)
Federal Aviation Administration Headquarters Building, Room 900E
800 Independence Avenue, SW.
Washington D.C. 20591

(iii) U.S. Department of Transportation
Branch Library
Federal Aviation Administration Headquarters Building, Room 930
800 Independence Avenue, SW.
Washington D.C. 20591

(3) FAA Noise Certification Specialists:

(i) Rotorcraft Noise Certification Specialist (ASW-110)
Federal Aviation Administration
Rotorcraft Directorate
2601 Meacham Boulevard
Fort Worth, Texas, 76137-4298

(mailing address:
DOT FAA
Fort Worth, Texas 76193-0110)

(ii) Small Airplane Noise Certification Specialist (ACE-111)
Federal Aviation Administration
Small Airplane Directorate
901 Locust, Room 301

Kansas City, Missouri, 64106

(iii) Transport Airplane Noise Certification Specialist (ANM-112)
Federal Aviation Administration
Los Angeles Aircraft Certification Office
3960 Paramount Blvd., Suite 100
Lakewood, California 90712-4137

Note: These Specialists are located in their respective Directorates.

(4) FAA Directorates:

(i) Engine and Propeller Directorate (ANE-100)
Federal Aviation Administration
12 New England Executive Park
Burlington, Massachusetts 01803-5299

(ii) Rotorcraft Directorate (ASW-100)
Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, Texas 76193

(iii) Small Airplane Directorate (ACE-100)
Federal Aviation Administration
1201 Walnut Street
Kansas City, Missouri 64106

(iv) Transport Airplane Directorate (ANM-100)
Federal Aviation Administration
1601 Lind Avenue Southwest
Renton, Washington 98055 -4056

Note: These Directorates are involved in aircraft certification and continued airworthiness activities.

(5) FAA Regional Headquarters:

(i) Alaskan Region Headquarters (AAL-1)
Federal Aviation Administration
222 West 7th Avenue, # 14
Anchorage, Alaska 99513-7587

(ii) Central Region Headquarters (ACE-1)
Federal Aviation Administration
601 East 12th Street
Federal Building
Kansas City, Missouri 64106

(iii) Eastern Region Headquarters (AEA-1)
Federal Aviation Administration
JFK International Airport
Fitzgerald Federal Building
Jamaica, New York 11430

(iv) Great Lakes Region Headquarters (AGL-1)

Federal Aviation Administration
O'Hare Lake Office Center
2300 East Devon Avenue
Des Plaines, Illinois 60018_4686

(v) New England Region Headquarters (ANE-1)
Federal Aviation Administration
12 New England Executive Park
Burlington, Massachusetts 01803-5299

(vi) Northwest Mountain Region Headquarters (ANM-1)
Federal Aviation Administration
1601 Lind Avenue Southwest
Renton, Washington 98055-4056

(vii) Southern Region Headquarters (ASO-1)
Federal Aviation Administration
1701 Columbia Avenue
College Park, Georgia 30337

(viii) Southwest Region Headquarters (ASW-1)
Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, Texas 76137- 4298

(mailing address:
DOT/FAA
Fort Worth, Texas 76193-0001)

(ix) Western-Pacific Region Headquarters (AWP-1)
Federal Aviation Administration
15000 Aviation Blvd.
Hawthorne, CA 90261

(mailing address:
Western-Pacific Region Headquarters (AWP-1)
Federal Aviation Administration
PO Box 92007
Worldway Postal Center
Los Angeles, Ca, 90009)

(6) FAA Aircraft Certification Offices (ACO):

(i) Anchorage Aircraft Certification Office (ACE-115N)
Federal Aviation Administration
222 West 8th Avenue
Anchorage, Alaska 99513-7587

(ii) Atlanta Aircraft Certification Office (ACE-115A)
Federal Aviation Administration
One Crown Center
1895 Phoenix Boulevard, Suite 450
Atlanta, Georgia 30349

(iii) Boston Aircraft Certification Office (ANE-150)

Federal Aviation Administration
12 New England Executive Park
Burlington, Massachusetts 01803-5299

(iv) Brussels Aircraft Certification Staff (AEU-100)
Federal Aviation Administration
c/o American Embassy
15 rue de la Loi (1st Floor)
B-1040
Brussels, Belgium

(mailing address:
Federal Aviation Administration (AEU-100)
c/o American Embassy
PSC 82, Box 002
APO AE 09724)

(v) Chicago Aircraft Certification Office (ACE-115C)
Federal Aviation Administration
2350 East Devon, Room 332
Des Plaines, Illinois 60018

(mailing address:
Chicago Aircraft Certification Office (ACE-115C)
Federal Aviation Administration
2300 East Devon
Chicago, Illinois 60018)

(vi) Denver Aircraft Certification Office (ANM-100D)
Federal Aviation Administration
Technical Operations Center
26805 East 68th Avenue, Room 214
Denver, Colorado 80249

(vii) Engine Certification Office (ANE-140)
Federal Aviation Administration
12 New England Executive Park
Burlington, Massachusetts 01803-5299

(viii) Fort Worth Aircraft Certification Office (ASW-150)
Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, Texas 76137-4298

(mailing address:
DOT FAA
Fort Worth, Texas 76193-0150)

(ix) Fort Worth Rotorcraft Certification Office (ASW-170)
Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, Texas 76137-4298

(mailing address:
DOT FAA

Fort Worth, Texas 76193-0170

(x) Fort Worth Special Certification Office (ASW-190)
Federal Aviation Administration
2601 Meacham Boulevard
Fort Worth, Texas 76137-4298

(mailing address:
DOT FAA
Fort Worth, Texas 76193-0190

(xi) Los Angeles Aircraft Certification Office (ANM-100L)
Federal Aviation Administration
3960 Paramount Boulevard, Suite 100
Lakewood, California 90712-4137

(xii) New York Aircraft Certification Office (ANE-170)
Federal Aviation Administration
10 Fifth Street, 3rd Floor
Valley Stream, New York 11581-1200

(xiii) Seattle Aircraft Certification Office (ANM-100S)
Federal Aviation Administration
1601 Lind Avenue Southwest
Renton, Washington 98055-4056

(xiv) Wichita Aircraft Certification Office (ACE-115W)
Federal Aviation Administration
Mid-Continent Airport
FAA Building, Room 100
1801 Airport Road
Wichita, Kansas 67209

Note: An applicant must coordinate airworthiness and noise certification activities with the appropriate ACO Office. Assistance in selecting the appropriate ACO Office may be obtained from FAA Directorate, Regional or Noise Certification Specialist Offices.

c. Procedures

None

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 is applied for under § 21.93(b) of this chapter.

33. Section 36.7(b)

General requirements. Except as otherwise specifically provided, for each airplane covered by this section, the acoustical change approval 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 section 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, for an airplane for which application is made after September 17, 1971--
(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 FAA 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, FAA 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 FAA 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) If compliance with Stage 3 noise levels is not required before the change in type design, the airplane must--
(I) Be a Stage 2 airplane after the change in type design and compliance must be shown under the provisions of paragraph (d)(1) or (d)(2) of this section, as appropriate; or
(ii) Remain a Stage 3 airplane after the change in type design. Compliance must be shown under the provisions of paragraph (e)(2) of this section.
(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) Applications on or after [August 14, 1989.] The airplane must remain a Stage 3 airplane after the change in type design.

a. Explanation

None

b. Supplemental Information

(1) "Dual-Stage" Certificated Airplanes: Some older airplane models have been certificated to Stage 2 for one configuration and to Stage 3 for another configuration (e.g., airplane takeoff flap setting or maximum allowable gross weights). These airplanes are classified as "Dual-Stage" certificated airplanes. No new dual certifications will be considered.

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 is applied for under § 21.93(b) of this chapter on or after March 6, 1986. 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 6,000 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 6,000 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 part s 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 FAA, 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 FAA 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 6000 lbs (2727 kg): 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 and Stage 3 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 approved equivalent procedure

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 FAA. 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 FAA has approved their application for any current or future aircraft noise certification actions (See Supplemental Information Items in Subpart O, section 1501, regarding the FAA'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 FAA 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) Equivalent Procedures: The FAA is not authorized to approve equivalencies for reference procedures.

(3) Flight Test Guide: General approved flight test procedures, principles, methods and flight crew operational practices are included in AC 25-7A, Flight Test Guide (See reference 6 of this AC).

c. Procedures

None

54. Section 36.103(b)

Type certification applications for subsonic transport category large airplanes and all subsonic jet airplanes must show that the noise levels of the airplane are no greater than the Stage 3 noise limits stated 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

IV. SUBPART C—RESERVED

V. SUBPART D—NOISE LIMITS FOR SUPERSONIC TRANSPORT CATEGORY AIRPLANES

No technical guidance has been developed for the following sections:

55. Section 36.301 Noise limits: Concorde
56. Section 36.301(a)
57. Section 36.301(b)

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 36.801(b) [To be completed later]

71. Section 36.805(c)

For helicopters for which application for issuance of an original type certificate in the primary, normal, transport, or restricted category is made on or after March 6, 1986, and which the FAA finds to be the first civil version of a helicopter that was designed and constructed for, and accepted for operational use by, an Armed Force of the United States or the U.S. Coast Guard on or before March 6, 1986, it must be shown that the noise levels of the helicopter are no greater than the noise limits for a change in type design as specified in section H36.305(a)(1)(ii) of Appendix H of this part for compliance demonstrated under appendix H of this part, or as specified in section J36.305 of appendix J of this part for compliance demonstrated under appendix J of this part. Subsequent civil versions of any such helicopter must meet the Stage 2 requirements.

a. Explanation

(1) Stage 1 helicopters: The provision applicable to a helicopter based on a military design is defined. Reference is included to Appendix J but the rule does not provide the "Stage 2 + 2 dB (SEL)" or "no noisier than the parent" provision similar to the limits under Appendix H provided in section H36.305. Thus, the noise compliance discussed is essentially related to certification under the provision of Appendix H.

b. Supplemental Information

(1) Stage 1 Helicopter: If section 36.805(c) applies, then noise testing will lead to one of the following:

a) The helicopter is demonstrated to be a Stage 2 helicopter: The tradeoff provisions in section H36.305(b) may be used to demonstrate compliance with the Stage 2 noise level requirement. The certificated helicopter is not designated as a first civil version, instead the certificated helicopter is designated as a Stage 2 helicopter;

b) The helicopter is demonstrated to be a Stage 1 helicopter via the "Stage 2 + 2 EPNdB" noise limits specified in section H36.305(a)(1)(ii) and is consequently designated as the first civil version. The trade provisions in section H36.305(b) may not be used for a first civil version; or

c) The helicopter fails to demonstrate compliance with the (Stage 2 + 2) noise limits specified in section H36.305(a)(1)(ii): The helicopter will be denied a type certificate until such time that the helicopter, modified as necessary, successfully demonstrates compliance with at least the requirements for a first civil version outlined above in outcome (b). The helicopter fails to demonstrate compliance if one or more of the demonstrated Appendix H noise levels exceeds the corresponding noise level limit or that flight procedure and the helicopter does not otherwise meet the Stage 2 limits (note: a helicopter may exceed the Stage 1 limit for a given flight procedure and yet achieve Stage 2 compliance through the use of tradeoffs).

(2) Change in Type Design: If an applicant has substantiated that a proposed change in type design (as designated in section 21.93) would be less noisy or no noisier than the (parent) first civil version

helicopter, no additional demonstration of compliance with part 36 is required. The derivative helicopter remains a first civil version. The applicant may elect to: (1) carry forward the parent's noise numbers to the rotorcraft flight manual of the derived version; or (2) voluntarily noise test the derivative helicopter in order to substantiate lower noise certification levels. However, if the derivative helicopter is found to be a Stage 2 helicopter as a result of the voluntary noise test, and if the applicant chooses to certify the derivative helicopter as a Stage 2 helicopter, that derivative helicopter is no longer classified as a first civil version.

(3) Subsequent Civil Version: The section 36.805(c) requirement for a subsequent civil version applies only to a helicopter previously designated as a first civil version. A subsequent civil version (unless otherwise excepted under section 21.93(b)(4) from the acoustical change requirements) is: (a) any change in type design of the first civil version that would result in one or more of the noise certification levels of the subsequent civil version that are greater than the corresponding noise certification levels of the first civil version; or (b) any change in the first civil version that is sufficient to require a new type certificate (as provided in section 21.19). As specified in section 36.805(c), a subsequent civil version must comply with the Stage 2 noise limits.

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

X. SUBPARTS I-N [RESERVED]

73. –75 [RESERVED]

XI. SUBPART E--RESERVED

XII. SUBPART O--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 FAA 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 FAA 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 FAA, 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 <u>all</u> Equivalent Procedures utilized (e.g., Flight Path Intercept Procedure).

(3) <u>NOISE COMPLIANCE DEMONSTRATION PLANS (Airplane Families)</u>: 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 FAA and either integrated into the basic noise compliance demonstration plan, or submitted to FAA 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);

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

(iii) 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 FAA approval, witness noise certification tests conducted in accordance with FAA approved noise compliance demonstration plans.

In cases where tests are witnessed by DERs, the FAA 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 FAA 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.

FAA Order 8110.4 B (reference 7 of this AC), paragraph 6-3(e)(3) specifies AEE as the FAA approving authority for Equivalent Procedures (See Note C). However, as experience is gained with the application of a particular procedure, AEE may delegate approval of the procedure to ACO or NCS specialists. (See FAA AEE Memorandum " Required Approval Level for Part 36 Subpart B and C Equivalent Procedures", dated August 19, 1998). For example, FAA policy currently permits NCS approval (or ACO approval when authority is delegated) of NPD equivalencies representing extensions of data used to demonstrate compliance with part 36 for original certified aircraft. NCS (or ACO) approval authority is limited to cases where either the NPD curve fit is linear and the proposed extension is not greater than 5 percent, or the NPD curve fit is 2nd order and the proposed extension is not greater than 2.5 percent. The NCS also has approval authority for use of existing NPD plots for amended type designs (excluding extrapolation and increments to NPD plots – See Note D).

Although equivalent procedures are usually treated by the FAA 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 FAA Advisory Circular 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 FAA 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., 3^{o} 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) <u>NO ACOUSTICAL CHANGE (NAC) DOCUMENTATION</u>: Aircraft type design changes that are categorized as NAC require FAA approval under the provisions of part 21 rather than part 36. Applicants' proposals for approval of NAC must be submitted to the FAA 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) Part 183 section 183.29(i) specifies that Acoustic DERs may not determine that a type design change is an NAC. As such, Acoustic DERs may not make recommendations for approval of NACs under form 8110-3.

(11) <u>OTHER NOISE RELATED DOCUMENTATION</u>: FAA is required to develop noise related documentation other than that required of applicants under part 36, Subpart O, section 1501 as follows:

a. <u>FINDINGS REQUIRED BY PUBLIC LAW 103-272 (reference 2 of this AC)</u>: Compliance with Public Law 103-272 requires that FAA, before issuing an original TC for any aircraft of any category, regardless of whether part 36 applies to the aircraft, must make a finding to determine whether:

(i) Substantial noise abatement cannot be achieved for that aircraft by prescribing standards and regulations consistent with the limitations of section 44715(b); or

(ii) Substantial noise abatement may be so achieved in which case the regulatory process must be used to determine the extent of noise reduction to be required before an original TC may be issued.

Note:
The specific process required for FAA to complete Noise Finding documentation is presented in FAA Order 8110.4 B (reference 7 of this AC), paragraph 6-3(c)

b. ENVIRONMENTAL ASSESSMENTS: Compliance with the National Environmental Policy Act of 1969 may require that the FAA conduct an Environmental Assessment (EA) as specified in Appendix 4, section 3(a) of FAA Order 1050.1D (reference 1 of this AC). An EA is conducted when type certificate actions (New, Amended, or Supplemental) are initiated for aircraft types for which part 36 requirements do not exist (See Note A). An Environmental Impact Statement (EIS) or Finding of No Significant Impact (FONSI) must be prepared by the FAA (See Note B). The FAA may grant an interim aircraft noise certification upon completion of an EA while appropriate rulemaking is being completed.

Notes:

A. Applicants may be requested to provide appropriate noise data to FAA to support the EA and/or rulemaking processes

B. Procedures for generation of an EA, EIS or FONSI are also found in FAA Order 1050.1D

c. Procedures

(1) Applicant's Responsibility: Applicants are responsible to generate and submit to FAA 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 FAA 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 flyover as defined and required by Appendix F (or 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 flyover, lateral and approach as defined and required by Appendix H (or flyover for Appendix J) along with the maximum takeoff weight, maximum landing 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 FAA 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 FAA 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 FAA 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. FAA 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 14 CFR part 36, Appendix B, Stage 3 noise level requirements and were obtained by analysis of approved data from noise tests conducted under the provisions of part 36, Amendment 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 FAA 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 FAA,

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-FAA approved section or page of the AFM or RFM.

82. Section 36.1581(c)

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

No determination has been made by the Federal Aviation Administration 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 FAA does not appraise aircraft in terms of their index of acceptability as related to airport operations.

b. Supplemental Information

(1) Certification vs. Operational Rule: Part 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 part 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 FAA approval prior to the aircraft entering service. The approved flight manual must list the certificated noise levels shown to comply with part 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 powered 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 flyover, lateral, 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 FAA-approved manual material, or on an FAA 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--

(1) Are designed for "agricultural aircraft operations" (as defined in § 137.3 of this chapter, effective on January 1, 1966) or for dispensing fire fighting materials; and
(2) Have not been shown to comply with the noise levels prescribed under Appendix F of this part --
iI) For which application is made for the original issue of a standard airworthiness certificate and that do not have any flight time before January 1, 1980, or
(ii) For which application is made for an acoustical change approval, for airplanes which have a standard airworthiness certificate after the change in the type design, and that do not have any flight time in the change configuration before January 1, 1980.

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, as defined in part 137.3, 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, as defined in part 137.3, 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 part 36 and must be operated in accordance with the noise operating limitation prescribed under FAR § 91.815.

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, in accordance with the restrictions of part 91, section 91.815, 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]

XIII. APPENDIX A TO Part 36-AIRCRAFT NOISE MEASUREMENT AND EVALUATION UNDER § 36.101

100. Appendix A to Part 36-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.

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 FAA 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 FAA 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 FAA 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 ACO noise specialist allowing sufficient calendar time (usually 2 months prior to the scheduled test) to permit adequate FAA 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 FAA 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, 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 (25 foot-radius) 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. FAA has approved noise measurements during winter conditions when snow within a 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 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 FAA 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 95°F (35°C) and not below 14°F (-10°C), and relative humidity not above 95% and not below 20% over the whole noise path between a point 33 ft (10 m) above the ground and the airplane;

***<u>Note:</u>* 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. <u>Explanation</u>

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. <u>Supplemental Information</u>

(1) <u>Assumed Ground Atmospheric Conditions</u>: 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) <u>Criteria for Measuring Atmospheric Conditions</u>: 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. <u>Procedures</u>

(1) <u>Atmospheric Measurements</u>: 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) <u>Applicant's Responsibility</u>: The applicant is responsible for providing the required meteorological measurement system that was approved in the noise compliance demonstration plan.

113. <u>Section A36.2.2.2(c)</u>

Relative humidity and ambient temperature over the whole noise path between a point 33 ft (10 m) 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 $\pm 0.9^{o}F$ ($\pm 0.5^{o}C$) 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. <u>Explanation</u>

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 sound attenuation coefficients vary over the PNLTM sound propagation path by more than ±1.6dB/1000ft (±0.5dB/100m) in the 3150Hz one-third octave band from the value of the atmospheric sound attenuation coefficient derived from the meteorological measurement obtained at 33 ft (10 m) 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 FAA 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 sound attenuation 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 Advisory Circular. 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, %	α (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 (α3,150) 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 33 ft (10 m) 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 33 ft (10 m) 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 15 knots

(ii) Maximum crosswind velocity is not to exceed 10 knots

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

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

The FAA 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 FAA 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 10- and 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 FAA; 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 FAA with the information. Acceptability of the wind conditions over the propagation path will be determined by the FAA.

(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 FAA 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 FAA.

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 sound attenuation coefficient of the 3150 Hz one-third octave band is not greater than ±1.6 dB/1000 ft (±0.5 dB/100m), with a minimum layer depth of 100 ft (30 m). This requirement must be met for the propagation path at PNLTM. The mean of the values of the atmospheric sound attenuation coefficients at the top and bottom of each layer may be used to characterize the attenuation 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 (α3,150) 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 one-third-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 Advisory Circular 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 approved by the FAA 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 FAA. 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: ±1.1 knots (±2.0 km/h) above 2.0 knots (3.7 km/h)

(B) Wind Direction: ±5 degrees

(C) Temperature: ±1.0 degree F (±0.5 degree C)

(D) Relative Humidity: ±3 percent

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

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 FAA.

a. Explanation

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

b. Supplemental Information

(1) Airplane Position Measurement: The FAA has approved several methods for measurement of airplane position. Additional guidance is also provided in section 6.5 of the appended ICAO TM. The FAA 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 FAA 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. FAA approval of airplane position measurement systems requires demonstrated accuracy and system documentation.

(2) Independent Airplane Position Determination: The FAA 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

the aircraft to assist the flight crew during noise certification tests. These systems such as microwave space 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: FAA-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 FAA-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 US Department of Transportation's Volpe National Transportation Systems Center (VNTSC) about the software used. VNTSC will determine whether the software satisfies part 36 requirements. All TSPI equipment and software must be demonstrated to and approved by the FAA 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 FAA.

(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 FAA.

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 FAA 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 1 V) 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 73.4°F (23°C);
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 FAA 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: FAA 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 VNTSC before FAA 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: FAA Order 8110.4B (reference 7) provides an FAA policy and procedure to promote uniform implementation of the noise certification requirements of part 36. Each applicant must submit information to VNTSC about the measurement, recording, and analysis instrumentation and software used. VNTSC will determine whether any listed components require evaluation for approval by FAA.

(2) Changes in Measurement System Configuration: If an applicant makes changes to the approved instrumentation, VNTSC must be notified before aircraft noise certification testing, to determine whether additional evaluation and FAA 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 FAA on the basis of demonstrated equivalent overall electro-acoustical 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 4 ft (1.2 m) 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.

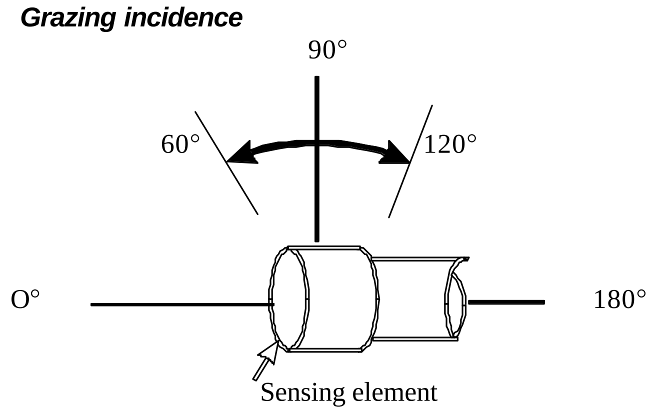


Figure A36-1: Illustration of Sound Incidence Angles on a Microphone

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.

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

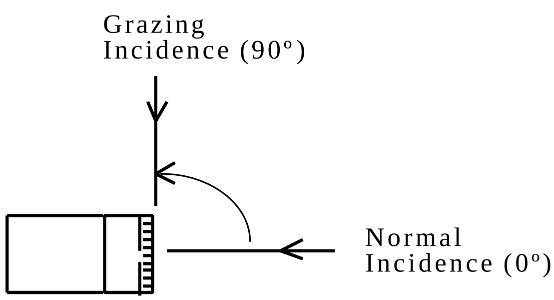
Table A36-1 Microphone Directional Response Requirements

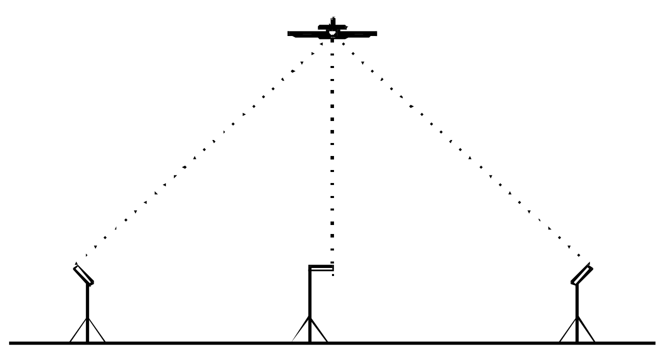
a. Explanation

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 to10 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 FAA 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., $20*\log_{10}(2^{16})$). 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 one-third-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. <u>Section A36.3.7.5</u>

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:

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

where $L_s(i,k)$ is the simulated slow time-weighted sound pressure level and $L(i,k)$ is the as-measured 0.5 s 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. For k =1, the slow time-weighted sound pressure $L_s[i,(k-1=0)]$ 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 $k \geq 4$:

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

where $L_s(i,k)$ is the simulated slow time-weighted sound pressure level and $L(i,k)$ is the as measured 0.5s 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 s after initiation of data analysis.

<u>Note:</u> The coefficients in the two equations were calculated for use in determining equivalent slow time-weighted sound pressure levels from samples of 0.5 s time average sound pressure levels. The equations do not work with data samples where the averaging time differs from 0.5 s.

170. <u>Section A36.3.7.6</u>

The instant in time by which a slow time-weighted sound pressure level is characterized must be 0.75s earlier than the actual readout time.

<u>Note:</u> The definition of this instant in time is needed 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 0.5 second data record this instant in time may also be identified as 1.25 seconds after the start of the associated 2 second averaging period.

171. <u>Section A36.3.7.7</u>

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

a. <u>Explanation</u>

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. FAA 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 FAA 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 FAA 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

FAA 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 ±30° 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 0.5 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 the U.S. National Institute of Standards and Technology or to an equivalent national standards laboratory as determined by the FAA. 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 FAA 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 the U.S. National Institute of Standards and Technology or to an equivalent national standards laboratory as determined by the FAA. 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 FAA 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 the U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA. 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 FAA and applied to the measured one-third octave sound pressure levels determined from the output of the analyser.

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 U.S. National Institute of Standards and Technology or an equivalent national standards laboratory as determined by the FAA.

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 signal-conditioning 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 NIST or an equivalent national standards laboratory as determined by the FAA.

(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 $\pm$ 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 $\pm$ 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 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 FAA; 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

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:

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

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

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-octave-band 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:

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

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

$$\bullet$$

$$\bullet$$

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

$$\bullet$$

$$\bullet$$

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

(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:

$$\mathrm{SPL}'(i,k) = \tfrac{1}{2}\left[\mathrm{SPL}(i-1,k) + \mathrm{SPL}(i+1,k)\right]$$

(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:

$$\bar{s}(i,k) = \tfrac{1}{3}\left[s'(i,k) + s'(i+1,k) + s'(i+2,k)\right]$$

(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:

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

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

.

.

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

.

.

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

a. Explanation

Steps 4 through 7 specify methods to smooth one-third-octave-band spectra to obtain pseudo-broadband 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) Step 8: Calculate the differences, F (i,k), between the original sound pressure level and the final background sound pressure level as follows:

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

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.

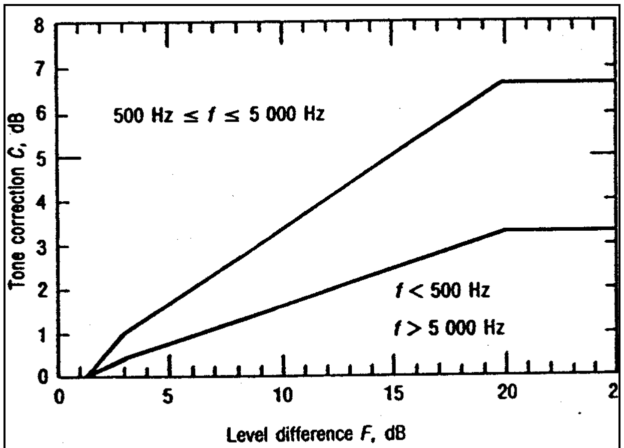
b. Supplemental Information

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.



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

* See Step 8, 4.3.1.

Table A36-2: Tone Correction Factor

a. <u>Explanation</u>

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

b. <u>Supplemental Information</u>

None

c. <u>Procedures</u>

None

(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 of 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:

$$\mathrm{PNLT}(k) = \mathrm{PNL}(k) + C(k)$$

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.

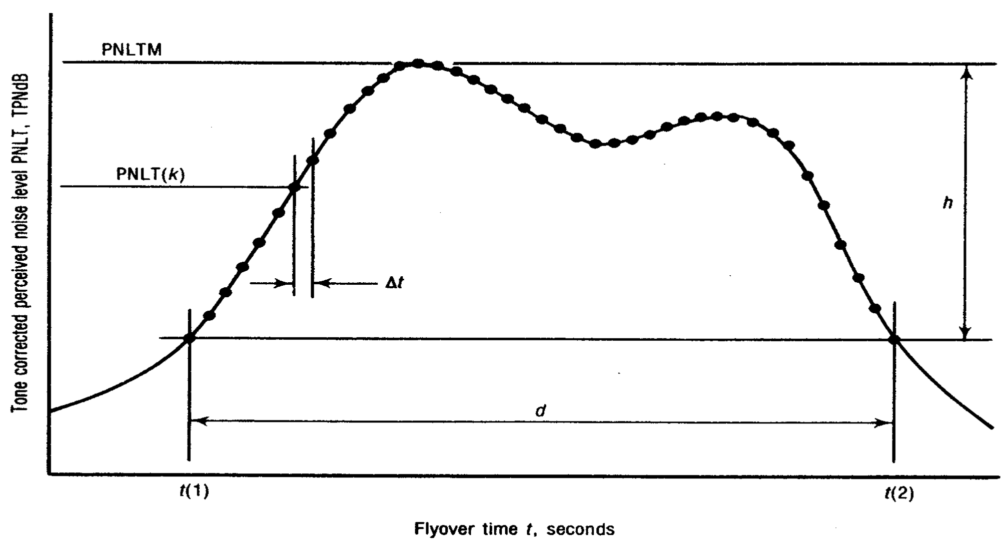


Figure A36-2: Example of Perceived Noise Level Corrected for Tones as a Function of Aircraft Flyover Time

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 identify 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 PNLTr at time of PNLTM before “delta 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 PNLTr at time of PNLTM (this includes two data records prior to PNLTr at time of PNLTM, the PNLTr at time of PNLTM record, and two data records after PNLTr 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:

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

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:

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

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 0.5s 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:

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

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 ($10*\log_{10}$ (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)

$$\mathbf{SPL} \geq \mathbf{SPL}(a)$$

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

(b)

$$\mathbf{SPL}(b) \leq \mathbf{SPL} < \mathbf{SPL}(a)$$

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

(c)

$$\mathbf{SPL}(e) \leq \mathbf{SPL} < \mathbf{SPL}(b)$$

$$n = \mathbf{0.3antilog}\{M(e)[\mathbf{SPL} - \mathbf{SPL}(e)]\}$$

(d)

$$\mathbf{SPL}(d) \leq \mathbf{SPL} < \mathbf{SPL}(e)$$

$$n = \mathbf{0.1\ antilog}\{\mathbf{M}(d)[\mathbf{SPL} - \mathbf{SPL}(d)]\}$$

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

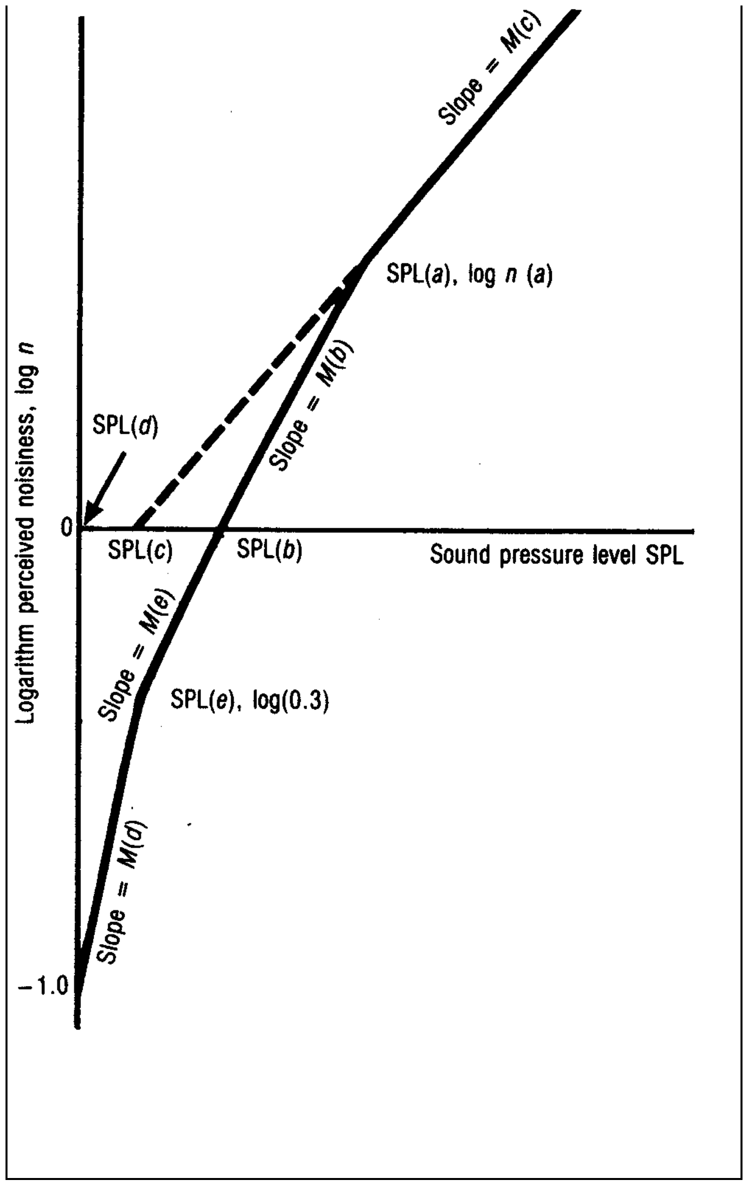


Figure A36-3: Perceived noisiness as a function of sound pressure level

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	79.9	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	NOT APPLICABLE	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		0.068160	0.037349
23	8 000	44.3	37	34	17	23	0.042285	0.029960	0.079520	”
24	10 000	50.7	41	37	21	29	”	”	0.059640	0.043573

Table A36-3: Constants for mathematically formulated noy values.

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

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 FAA, 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 FAA 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 FAA 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 FAA, 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 FAA for compliance review and approval. Adjustments to the measured data are also to be submitted to the FAA for review and approval. The FAA 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

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;

(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 knots or kilometers per hour 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 FAA 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: FAA does not approve equivalent procedures for noise certification reference conditions.

(3) DER Information: Reference airplane performance is to be FAA approved based on approved data. This may require that a flight analyst DER with appropriate authority for part 36 reference airplane performance submit completed FAA Form 8110-3 for review by the approving FAA flight test branch of the ACO. (See the DER Guidance Handbook, reference 10 for additional information.)

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 per cent 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 per cent 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 per cent confidence limit not exceeding ±1.5 EPNdB. No test result may be omitted from the averaging process unless approved by the FAA.

Note: Permitted methods for calculating the 90 per cent 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 EPNLr (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 EPNLr Levels: The average values of EPNLr are to be reported in a noise certification compliance document for flyover, lateral, and approach. The average value of EPNLr for n clustered data points, L_1, L_2, - - - -, L_n, is: $L_{mean} = (L_1 + L_2 + - - - + L_n)(1/n)$. The average value of EPNLr 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 EPNLr, (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 FAA 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 $\pm$ 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 FAA 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 FAA 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 EPNLr 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: EPNLr 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 FAA in noise certification compliance documentation.

(4) Retest Requirements: The FAA 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).*
EPNLr	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	per cent	***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.***
Ds(*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 20μPa	***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 20μPa	***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 20μPa	***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 20μPa	***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 20μPa	***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.***
I	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.***
Δ*t*	s	***Time increment. The equal increments of time for which PNL(k) and PNLT(k) are calculated.***
T	s	***Normalizing time constant. The length of time used as a reference in the integration method for computing duration corrections, where T = 10s.***
t(°F)(°C)	°F °C	***Temperature. The ambient air temperature.***
α (*i*)	dB/100ft dB/100m	***Test atmospheric sound attenuation The atmospheric attenuation of sound that occurs in the i-th one-third octave band at the measured air temperature and relative humidity.***

$a(i)_o$	dB/100ft dB/100m	***Reference atmospheric sound attenuation*** ***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 V_2+10 kt (V_2 +19 km/h), takeoff thrust)***
A_2	degrees	***Second constant climb angle (Gear up, speed of at least V_2+10 kt (V_2 +19 km/h), after cut-back)***
d e	degrees	***Thrust cutback angles. The angles defining the points on the takeoff flight path at which thrust reduction is started and ended respectively.***
h	degrees	***Approach angle.***
h_r	degrees	***Reference approach angle.***
q	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. .***
m		***Engine noise emission parameter.***
D_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.***
D_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.***
D_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 sound 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 atmospheric sound attenuation, frequency, temperature, and humidity is expressed by the following equations.

A36.7.2(a) For calculations using the English System of Units:

$$a(i) = 10^{\left[2.05\log\left(f_0/1000\right) + 6.33\times10^{-4}q - 1.45325\right]}$$

$$+h(d)\times10^{\left[\log\left(f_0\right) + 4.6833\times10^{-3}q - 2.4215\right]}$$

and

$$d = \sqrt{\frac{1010}{f(0)}10^{\left(\log H - 1.97274664 + 2.288074\times10^{-2}q\right)}}$$

$$\times10^{\left(-9.589\times10^{-5}q^2 + 3.0\times10^{-7}q^3\right)}$$

where

$h(d)$ ***is listed in Table A36-4 and f_0 in Table A36-5;***

$a(i)$ ***is the attenuation coefficient in dB/1000 ft;***

q ***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):

$$a(i) = 10^{\left[2.05\log\left(f_0/1000\right) + 1.1394\times10^{-3}q - 1.916984\right]}$$

$$+h(d)\times10^{\left[\log\left(f_0\right) + 8.42994\times10^{-3}q - 2.755624\right]}$$

and

$$d = \sqrt{\frac{1010}{f_0}}10^{\left(\log H - 1.328924 + 3.179768 \times 10^{-2} q\right)}$$

$$\times\ 10^{\left(-\ 2.173716 \times 10^{-4} q^{2} + 1.7496 \times 10^{-6} q^{3}\right)}$$

where

$h\,(d)$ ***is listed in Table A36-4 and f_0 in Table A36-5;***

$a(i)$ ***is the attenuation coefficient in dB/100 m;***

q ***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 $h(d)$

d	$h(d)$	d	$h(d)$
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		

Table A36-5. Values of f_0

one-third octave center frequency	f_0 (Hz)	one-third octave center frequency	f_0 (Hz)
50	50	800	800
63	63	1000	1000
80	80	1250	1250
100	100	1600	1600
125	125	2000	2000
160	160	2500	2500
200	200	3150	3150
250	250	4000	4000
315	315	5000	4500
400	400	6300	5600
500	500	8000	7100
630	630	10000	9000

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. Reference 7 requires that adjustment procedures and analysis methods be reviewed and approved by FAA AEE. FAA requires an audit procedure conducted by VNTSC to ensure that data adjustment and analysis methods that are proposed by applicants satisfy requirements of current regulations and approved procedures (See Appendix 2 of this AC). Any changes, including software revisions, firmware upgrades, or instrumentation changes are subject to VNTSC review before they can be used for noise certification evaluations. Program validation should be planned and the required information submitted to the FAA very early in the certification cycle, since VNTSC evaluation and FAA approval may take longer than 18 months. FAA Order 8110.4B (reference 7) specifies that future amendments to part 36 will be evaluated by VNTSC to determine whether approved data adjustment methods and analysis methods will be subject to re-evaluation. Applicants will be notified if re-evaluation is required. An appropriate Directorate NCS will provide guidelines for such re-evaluations.

(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, 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 FAA-approved procedures. The applicant must submit all proposed data adjustment procedures to the FAA ACO for review and approval. The FAA may require submittal of extensive detailed information about the data adjustment process and analysis methods for evaluation and acceptance. The Volpe Center Acoustics Facility of the U.S. Department of Transportation's Research and Special Programs Administration (VNTSC) assists the FAA in the evaluation and approval of applicants' data adjustment and analysis methods.

(2) VNTSC 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 FAA approved noise demonstration compliance plan

(ii) Ensuring version control of all noise data analysis software and informing the cognizant FAA ACO 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 15 knots (28 km/h) true airspeed, test data and/or analysis approved by the FAA 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 FAA-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 FAA-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 FAA 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 15 knots (28 km/h) true airspeed).

(6) Other Adjustments to Noise Values: Part 36 is intended to produce accurate, repeatable, and comparable values of EPNLr. Some adjustments inherent in the FAA 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 FAA-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 FAA approval of noise data including those associated with equivalent procedures.

(ii) Obtaining FAA approval of noise data adjustment procedures and analysis methods.

(iii) Applying approved noise data adjustments used to determine values of EPNLr.

(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 EPNLr 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. Section 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.

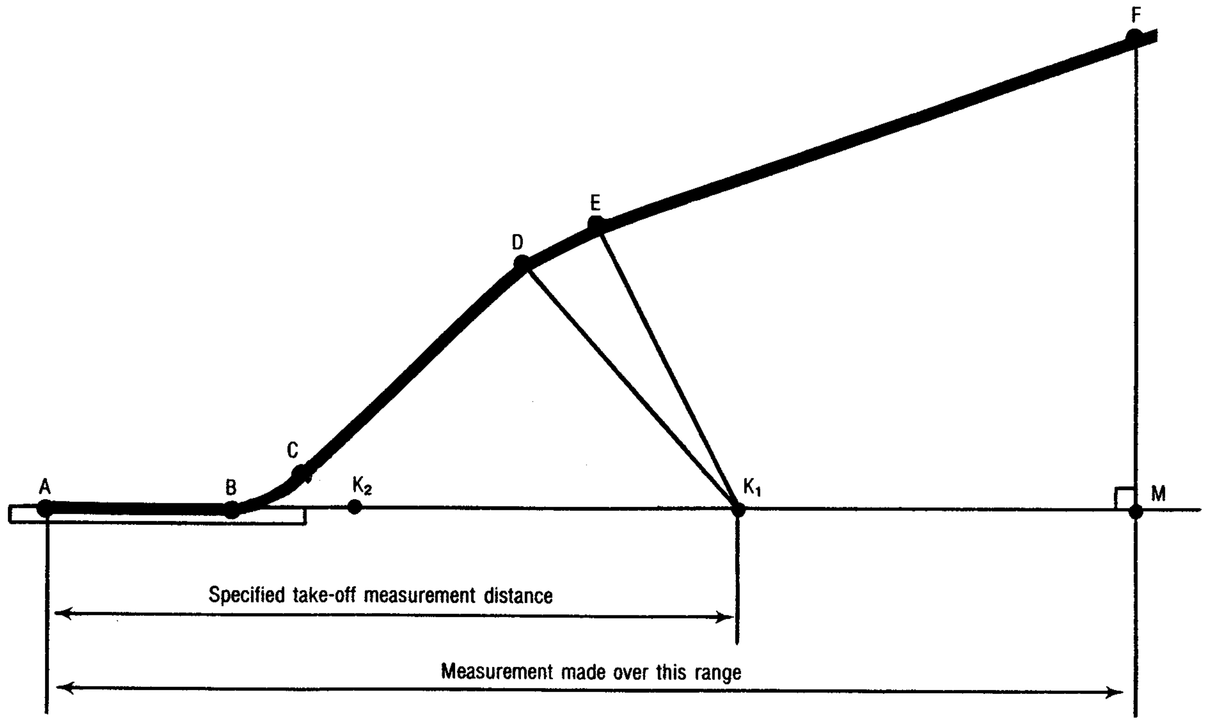


Figure A36-4. Typical Takeoff profile

a. Explanation

This section specifies the take-off flight test profiles for flyover noise measurements.

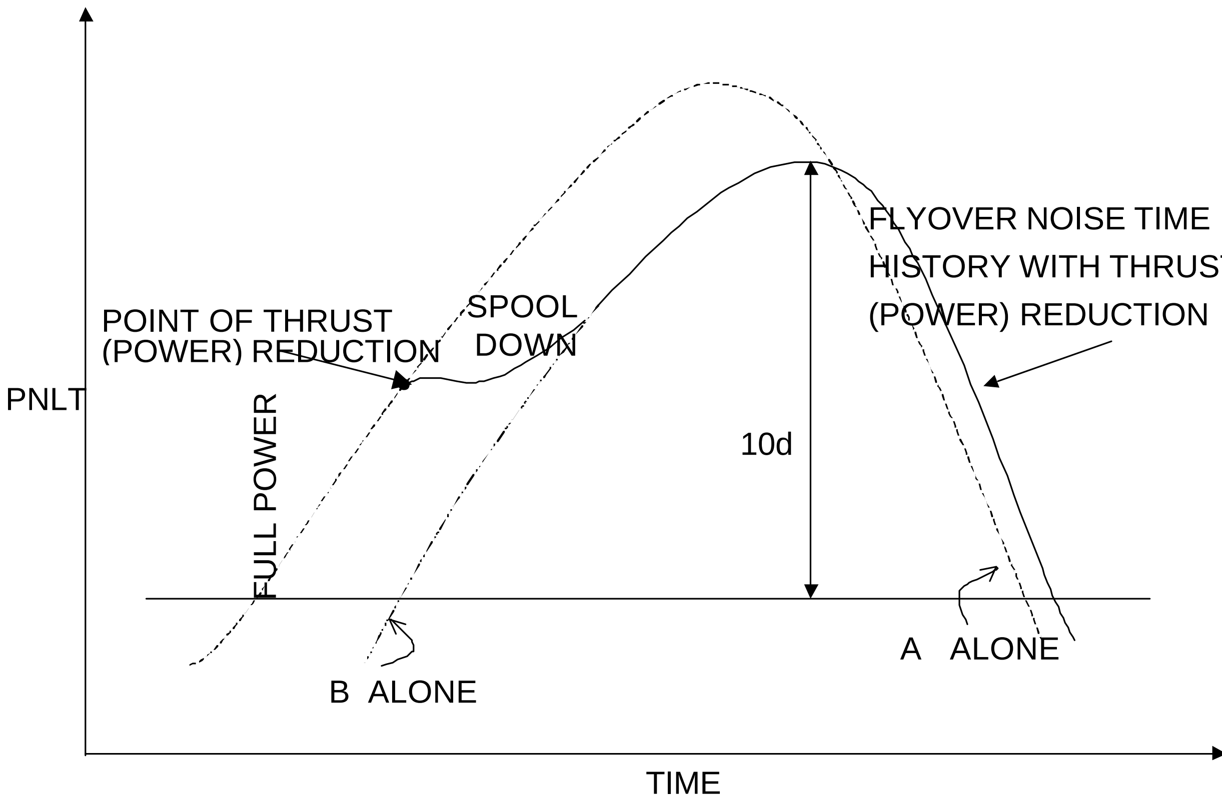
b. Supplemental Information

(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.

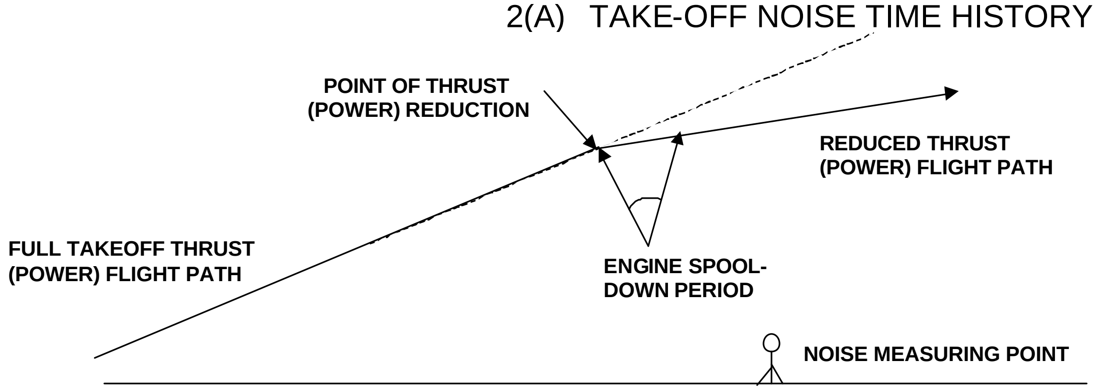
(2) Take-offs with Thrust (Power) Reduction: Take-offs with thrust (power) reduction are permitted to be included in the reference flyover noise certification procedure (and in the reference lateral noise certification procedure for tests conducted before August 7, 2002) for subsonic transport category 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 b. 3 or fewer turbojet engines c. Not powered by turbojet engines	a. All bypass ratios b. All bypass ratios c. Not applicable	a. 700 ft (214 m) b. 1,000 ft (305 m) c. 1,000 ft (305 m)
2	a. More than 3 turbojet engines b. 3 or fewer turbojet engines c. More than 3 turbojet engines d. 3 turbojet engines e. Fewer than 3 turbojet engines f. Not powered by turbojet engines	a. Less than 2.0 b. Less than 2.0 c. 2.0 or more d. 2.0 or more e. 2.0 or more f. Not applicable	a. 700 ft (214 m) b. 1,000 ft (305 m) c. 689 ft (210 m) d. 853 ft (260 m) e. 984 ft (300 m) f. 1,000 ft (305 m)
3	a. More than 3 engines b. 3 engines c. Fewer than 3 engines	a. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio. b. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio. c. Minimum cutback altitude for Stage 3 airplanes is not dependent on bypass ratio.	a. 689 ft (210 m) b. 853 ft (260 m) 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 August 7, 2002 (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.

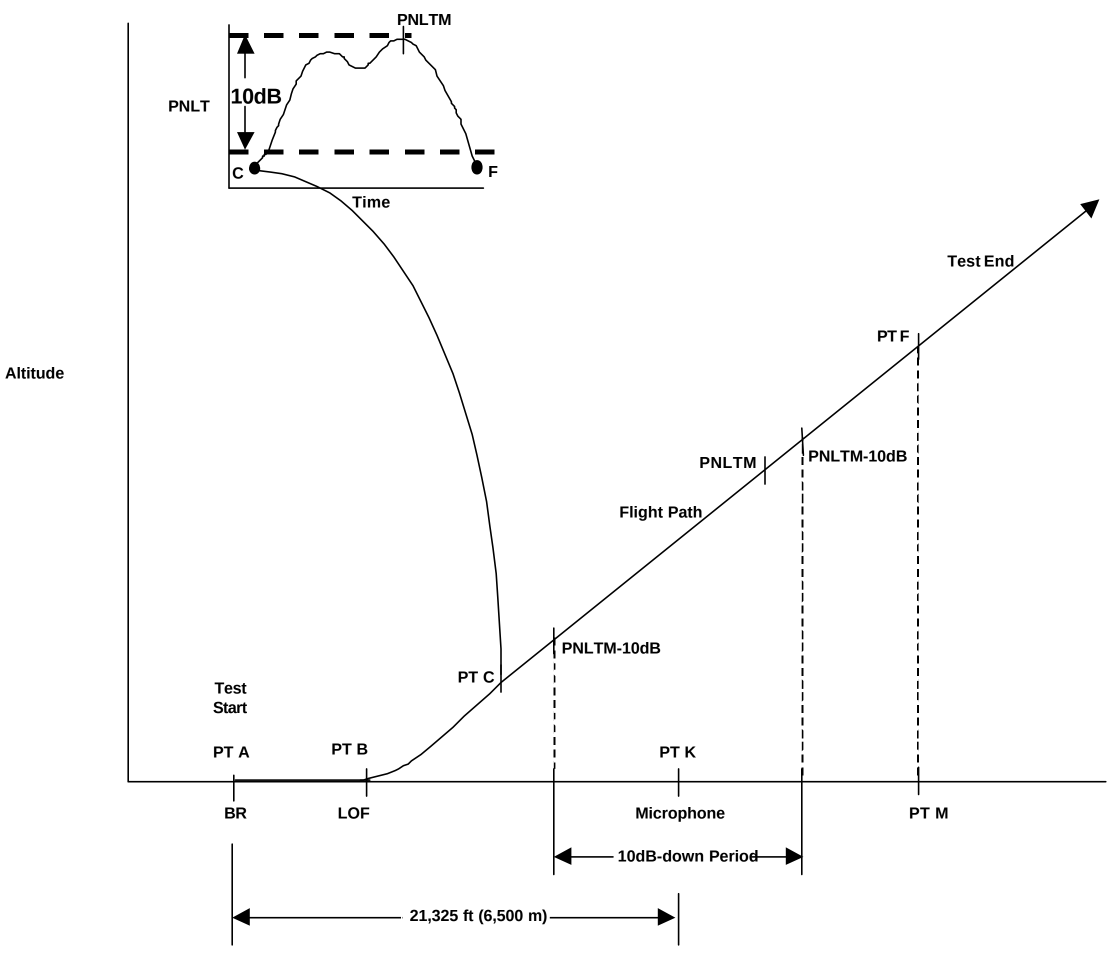


Figure 3: Normal Full Thrust (Power) Take-Off

(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.

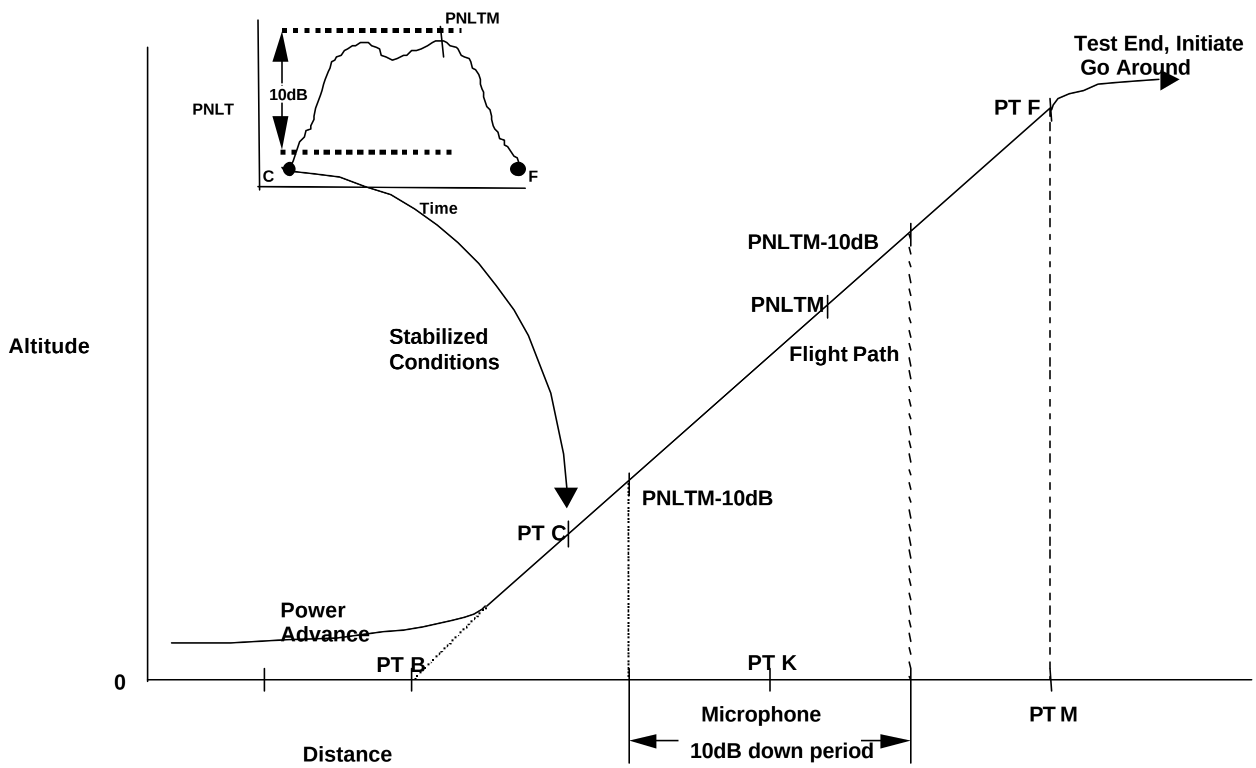


Figure 4: Flight Path Intercept Take-Off

(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.

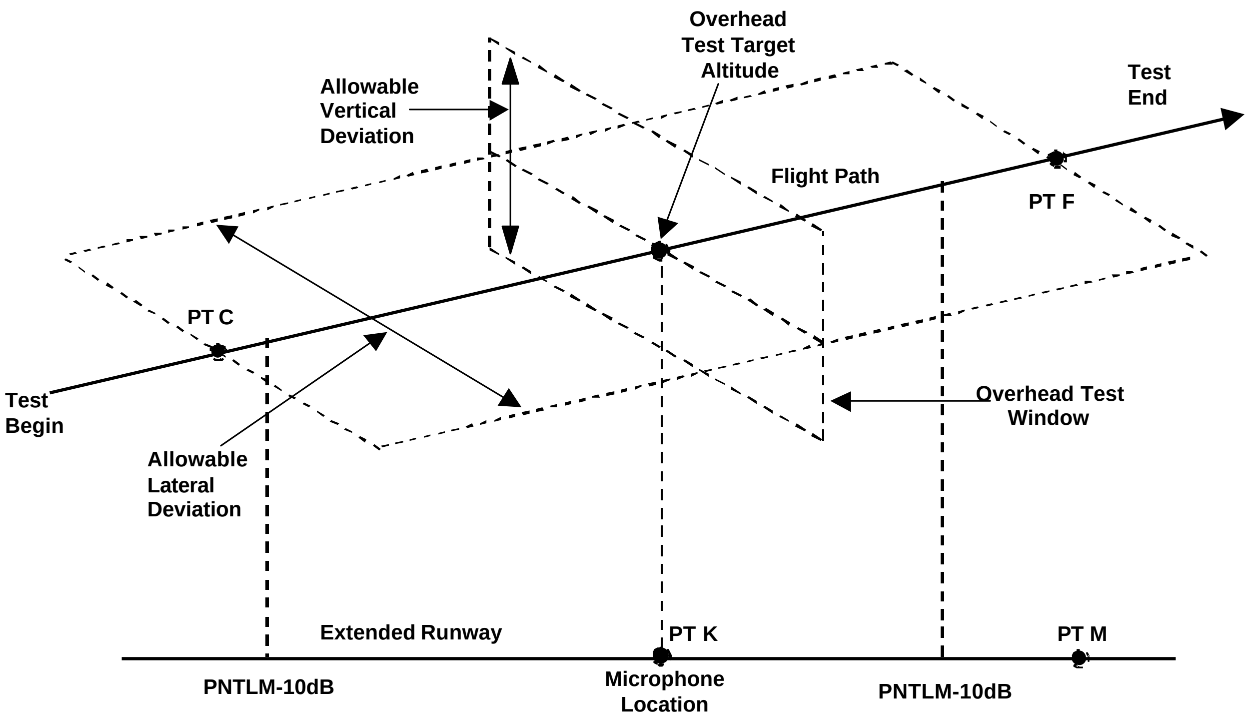


Figure 5: Take-Off Flight Path

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 August 7, 2002), 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 FAA 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. The airplane reference point for approach measurements is the instrument landing system (ILS) antenna. If no ILS antenna is installed an alternative reference point must be approved by the FAA.

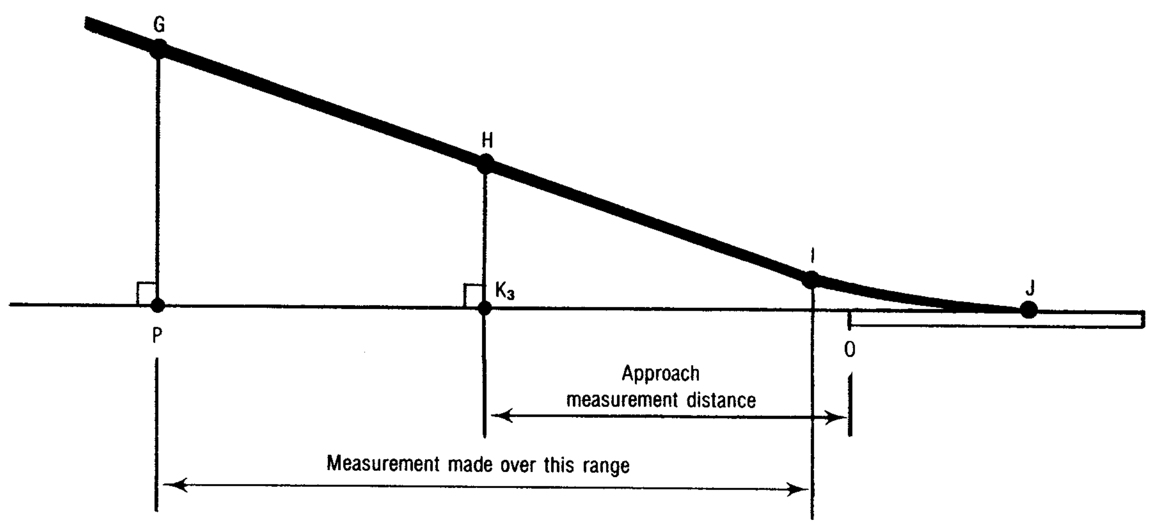


Figure A36-5. Typical Approach profile

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.

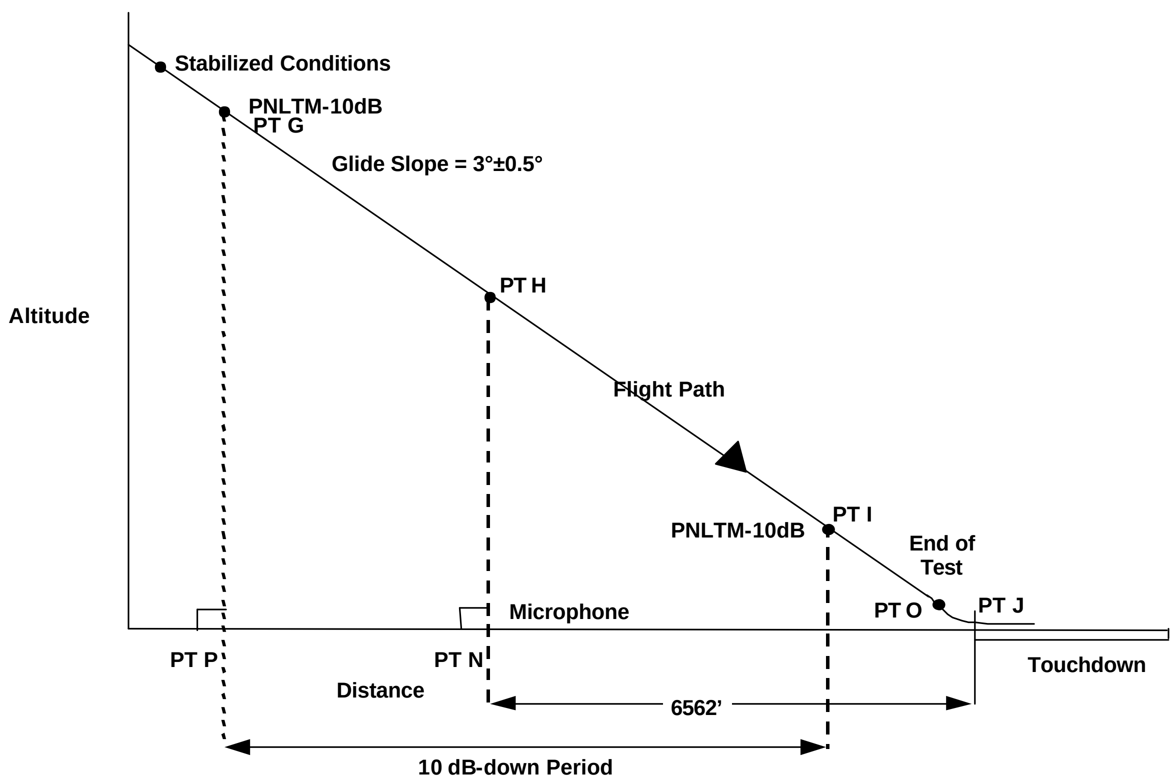


Figure 6: Approach With Full Landing

(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.

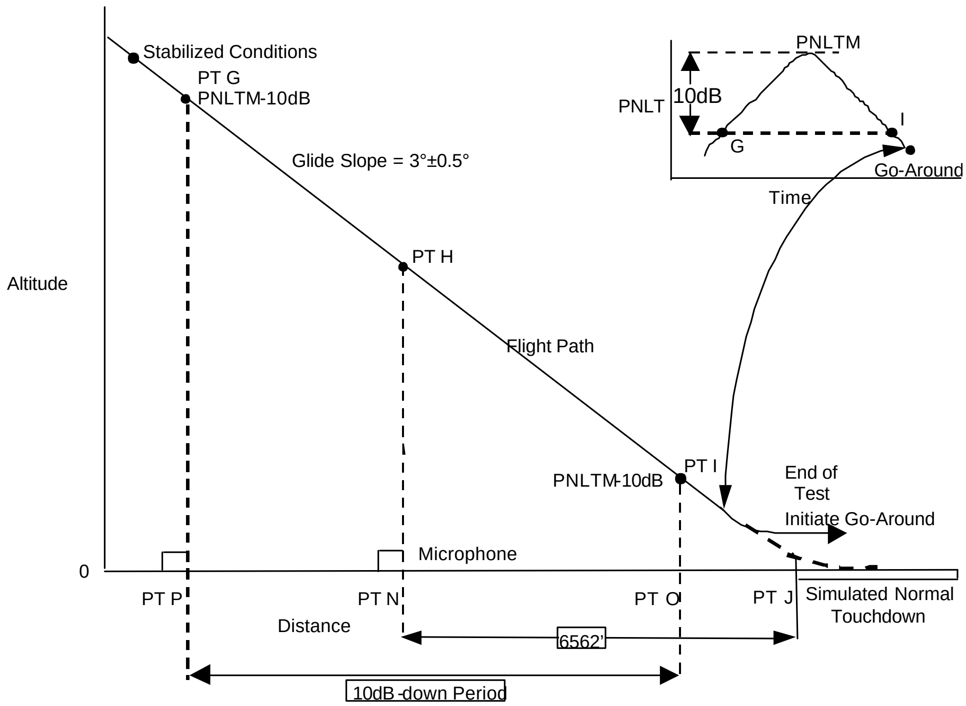


Figure 7: Flight Path Intercept Approach

(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.

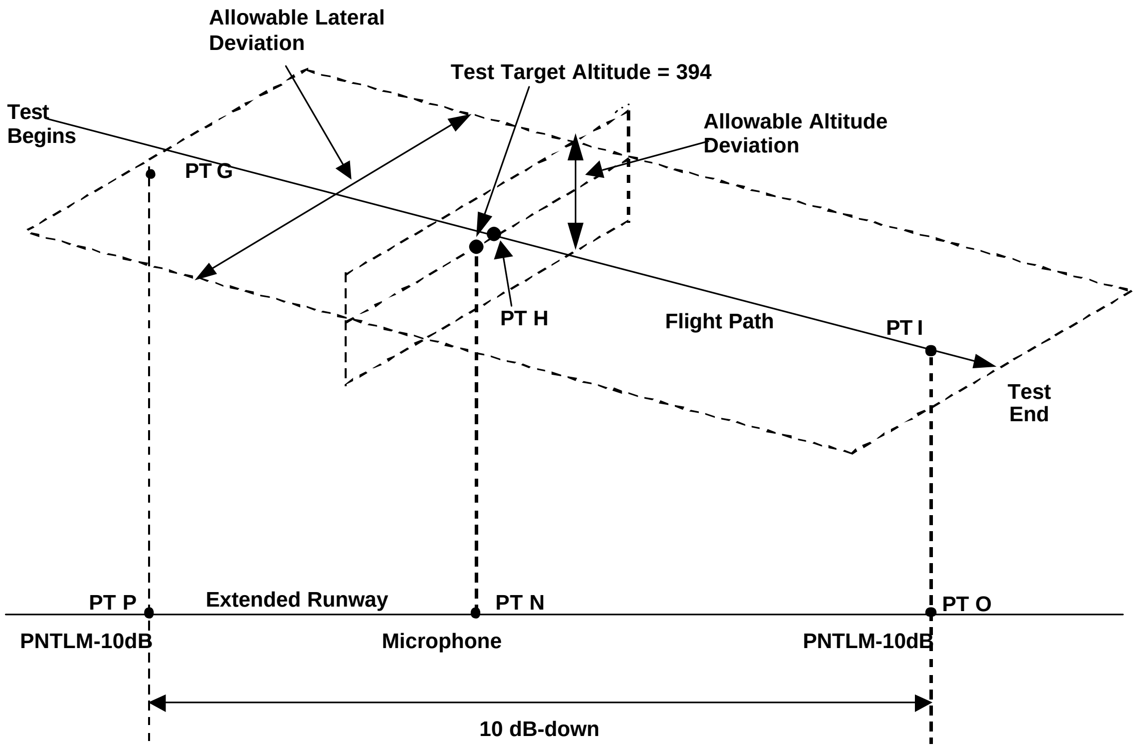


Figure 8: Approach Flight Path Deviations

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 FAA 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.

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

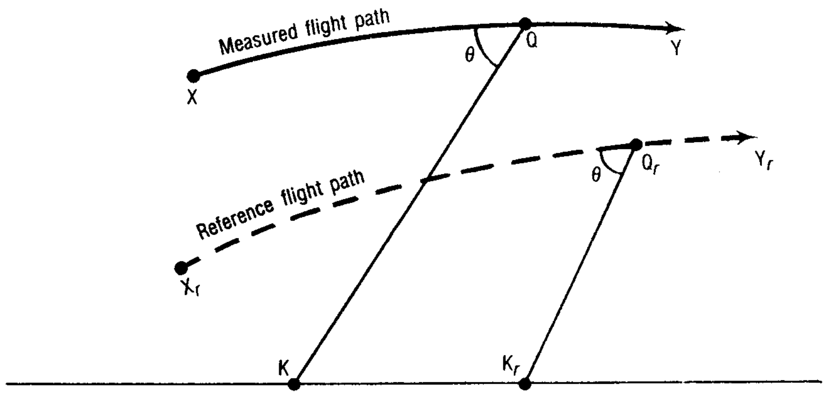


Figure A36-6. Profile characteristics influencing sound level

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 below, 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 K_r the reference measuring station. QK and Q_rK_r are, respectively, the measured and reference noise propagation paths. In this case K_r 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

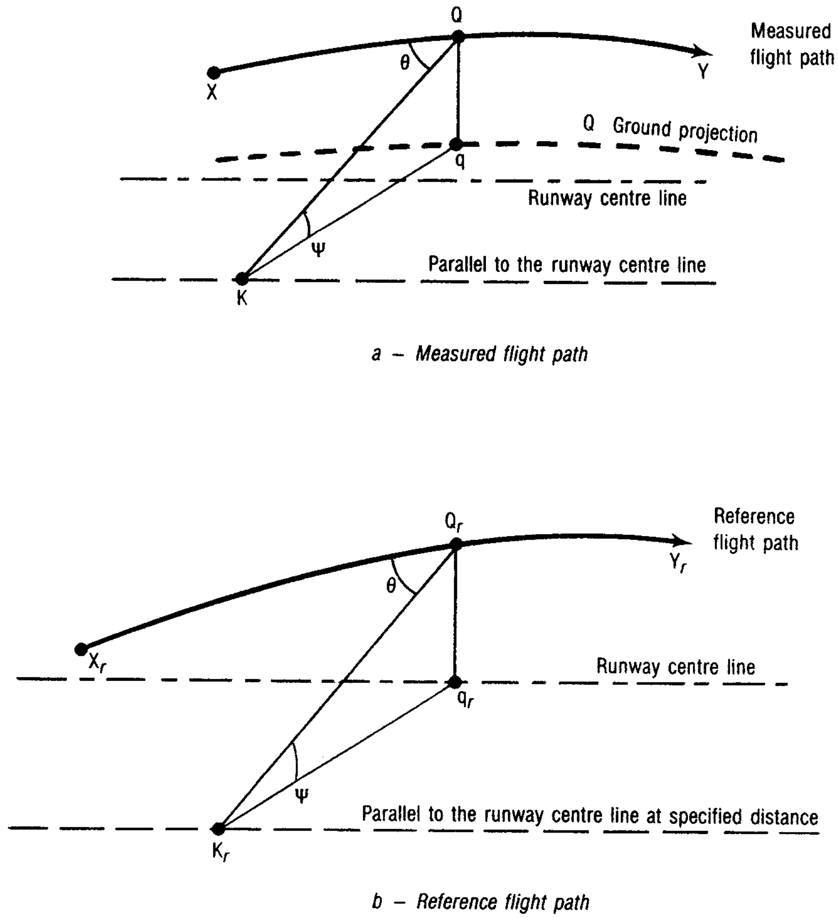


Figure A36-7. Lateral measurement - determination of reference station

(ii) Form the same angle y ***with the ground.***

<u>Note:</u> For the lateral noise measurement, sound propagation is affected not only by inverse square and atmospheric sound attenuation, but also by ground absorption and reflection effects which depend mainly on the angle y**.**

a. <u>Explanation</u>

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. <u>Supplemental Information</u>

None

c. <u>Procedures</u>

None

247. Section 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:

$$\begin{aligned}\mathrm{SPL}(i)_r &= \mathrm{SPL}(i) + 0.001[a(i) - a(i)_0]\mathrm{QK} \\ &+ 0.001a(i)_0(\mathrm{QK} - \mathrm{Q}_r\mathrm{K}_r) \\ &+ 20\log(\mathrm{QK}/\mathrm{Q}_r\,\mathrm{K}_r)\end{aligned}$$

In this expression,

(1) The term $0.001[a(i) - a(i)_0]\mathrm{QK}$ ***is the adjustment for the effect of the change in atmospheric sound attenuation coefficient, and*** a ***(i) and*** a ***$(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;***

(2) The term $0.001a(i)_0(\mathrm{QK} - \mathrm{Q}_r\mathrm{K}_r)$ ***is the adjustment for the effect of the change in the noise path length on the sound attenuation;***

(3) The term $20\log(\mathrm{QK}/\mathrm{Q}_r\,\mathrm{K}_r)$ ***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 feet and a ***(i) and*** a ***$(i)_O$ are expressed in dB/1000 ft.***

A36.9.3.2.1(b) For calculations using the International System of Units:

$$\begin{aligned}\mathrm{SPL}(i)_r &= \mathrm{SPL}(i) + 0.01[a(i) - a(i)_0]\mathrm{QK} \\ &+ 0.01a(i)_0(\mathrm{QK} - \mathrm{Q}_r\mathrm{K}_r) \\ &+ 20\log(\mathrm{QK}/\mathrm{Q}_r\,\mathrm{K}_r)\end{aligned}$$

In this expression,

(1) The term $0.01[a(i) - a(i)_0]\mathrm{QK}$ ***is the adjustment for the effect of the change in atmospheric sound attenuation coefficient, and*** a ***(i) and*** a ***$(i)_0$ are the coefficients for the test and reference atmospheric conditions respectively, determined under section A36.7 of this appendix;***

(2) The term $0.01a(i)_0(\mathrm{QK} - \mathrm{Q}_r\mathrm{K}_r)$ ***is the adjustment for the effect of the change in the noise path length on the atmospheric sound attenuation;***

(3) The term $20\log(\mathrm{QK}/\mathrm{Q}_r\,\mathrm{K}_r)$ ***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 a ***(i) and*** a ***$(i)_O$ are expressed in dB/100 m.***

a. Explanation

This section specifies the required adjustments to flyover, lateral, and approach one-third-octave-band 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 noise measurement 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, α(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.

Convert the corrected values, $SPL(i)_r$, to $PNLT_r$;

(b) Calculate the correction term Δ_1 using the following equation:

$$\Delta_1 = \mathrm{PNLT}_r - \mathrm{PNLTM}$$

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 $\Delta 1$. 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 PNLTr 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 EPNLr.

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 Delta 2 (?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. Delta 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:

$$\Delta_2 = -7.5\log\left(QK/Q_r K_r\right) + 10\log\left(V/V_r\right)$$

(a) Add D2 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 FAA. Typical data used for this adjustment are illustrated in Figure A36-8 that shows a curve of EPNL versus the engine control parameter m, 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 m_r is required to calculate the source noise adjustments for lateral, flyover and approach noise measurements.

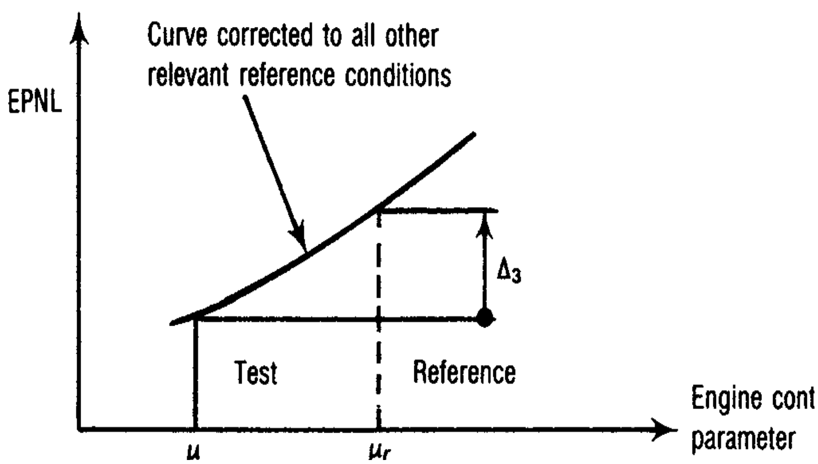


Figure A36-8: Noise Thrust Correction

256. Section A36.9.3.4.2

Calculate adjustment term D3 by subtracting the EPNL value corresponding to the parameter μ from the EPNL value corresponding to the parameter μ_r. Add D3 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.

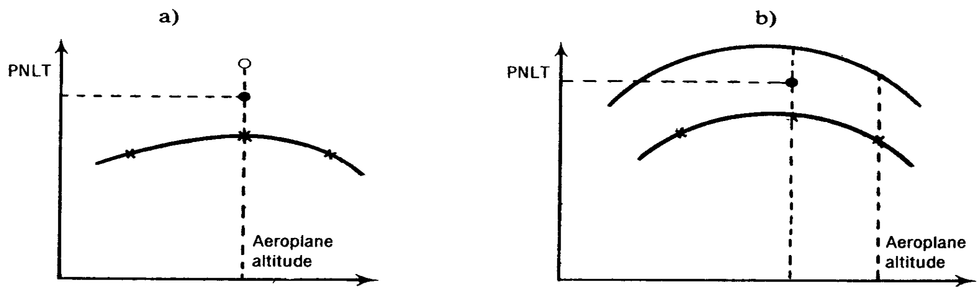


Figure A36-9: Symmetry Correction

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 re-computing 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:

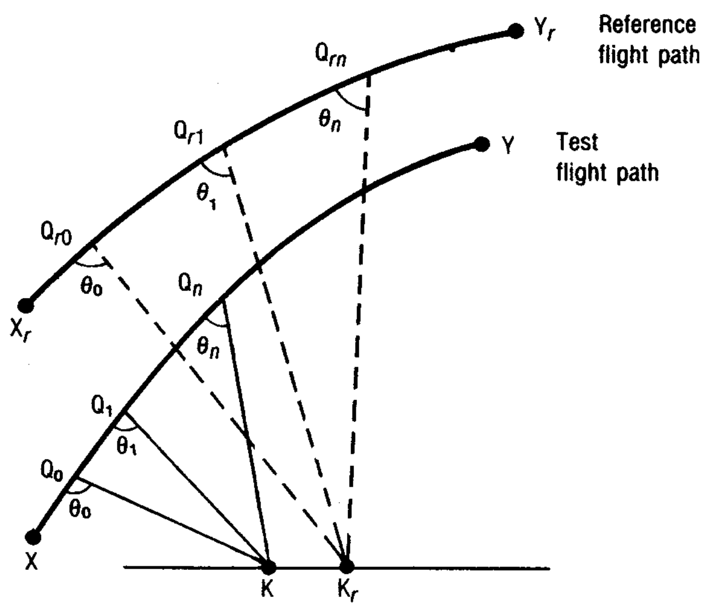


Figure A36-10: Correspondence between measured and reference flight paths for the application of the integrated methods of adjustment

(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 Q_0 and Q_n 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.

(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 and 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 Kr 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 so that between Q_{ro} 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 FAA. 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.

Note 1: 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.

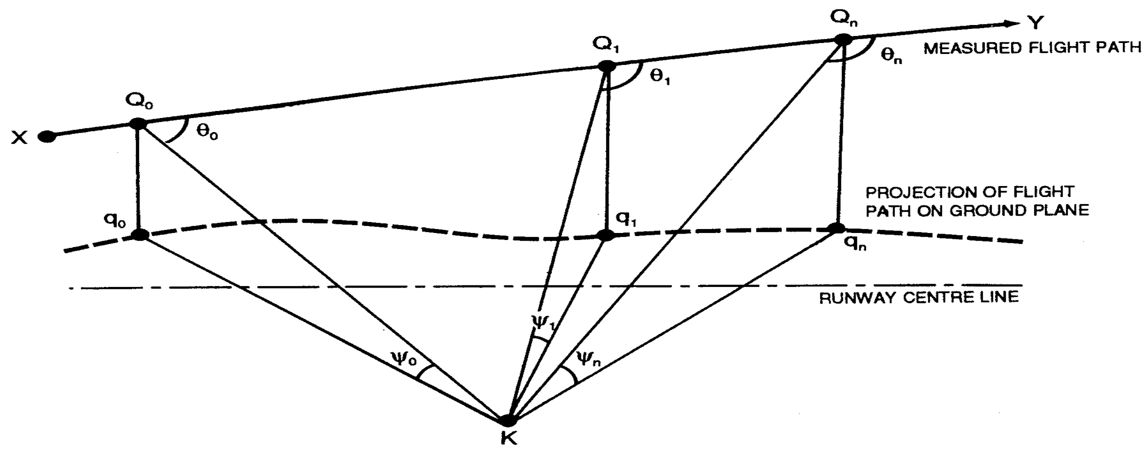


Figure A36-11(a): Measured Flight Path

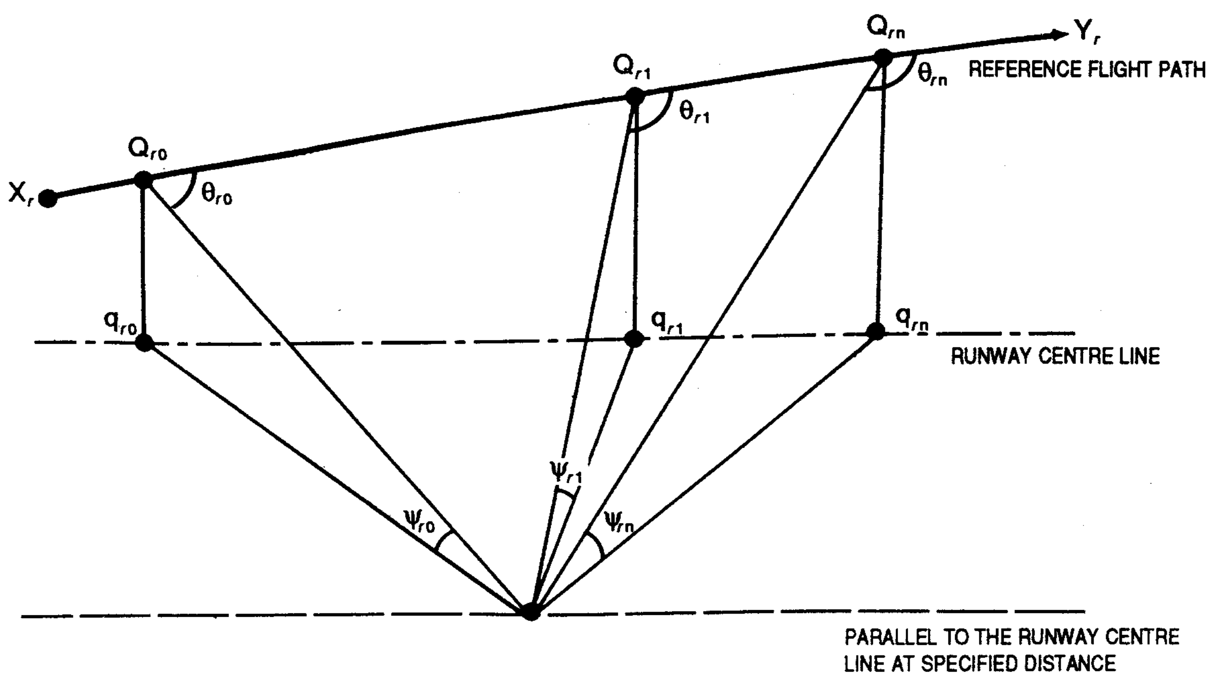


Figure A36-11(b): Reference Flight Path

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 FAA.

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 cut-back 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 EPNLr 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 PNLTr before calculation of the Duration Correction and EPNLr.

(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, D_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

XIV. APPENDIX B TO part 36--NOISE LEVELS FOR TRANSPORT CATEGORY AND JET AIRPLANES UNDER § 36.103

290. Appendix B to Part 36-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.

Compliance with this appendix must be shown with noise levels measured and evaluated using the procedures of appendix A of this part, or under approved equivalent procedures.

a. Explanation

This section specifies that an applicant's noise measurement and evaluation methods must conform to those of Appendix A or to FAA 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 1,476 feet (450 m) 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 0.35 nautical miles (648 m). For jet airplanes, when approved by the FAA, 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 985 feet (300 meters) altitude above ground level. A height of 1427 feet (435 meters) 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 +328 to -164 feet (+100 to -50 meters) 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 2,133 feet (650 meters). For tests conducted before August 7, 2002, 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 21,325 feet (6,500m) from the start of the takeoff roll;

(c) Approach reference noise measurement point: the point on the extended centerline of the runway that is 6,562 feet (2,000 m) from the runway threshold. On level ground, this corresponds to a position that is 394 feet (120 m) vertically below the 3° descent path, which originates at a point on the runway 984 feet (300 m) 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 FAA 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 33 feet (±10 meters) of each other.

a. Explanation

This section specifies FAA 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 FAA 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 FAA 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 FAA 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 600,000 pounds or more; for each halving of maximum weight (from 600,000 pounds), reduce the limit by 5 EPNdB; the limit is 93 EPNdB for a maximum weight of 75,000 pounds or less.

(2) Lateral and approach: 108 EPNdB for maximum weight of 600,000 pounds or more; for each halving of maximum weight (from 600,000 pounds), reduce the limit by 2 EPNdB; the limit is 102 EPNdB for a maximum weight of 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 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 44,673 pounds or less;

(ii) For airplanes with 3 engines: 104 EPNdB for maximum weight of 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 63,177 pounds or less; and

(iii) For airplanes with fewer than 3 engines: 101 EPNdB for maximum weight of 850,000 pounds or more; for each halving of maximum weight (from 850,000 pounds), reduce the limit by 4 EPNdB; the limit is 89 EPNdB for a maximum weight of 106,250 pounds or less.

(2) Lateral, regardless of the number of engines: 103 EPNdB for maximum weight of 882,000 pounds or more; for each halving of maximum weight (from 882,000 pounds), reduce the limit by 2.56 EPNdB; the limit is 94 EPNdB for a maximum weight of 77,200 pounds or less.

(3) Approach, regardless of the number of engines: 105 EPNdB for maximum weight of 617,300 pounds or more; for each halving of maximum weight (from 617,300 pounds), reduce the limit by 2.33 EPNdB; the limit is 98 EPNdB for a maximum weight of 77,200 pounds or less.

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, and Stage 3 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. FAA uses Equations A through E to determine these levels (limits).

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 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: FAA 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 FAA.
(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 sound attenuation coefficients.
(i) Sea level atmospheric pressure of 2116 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 EPNLr 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^o 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--700 feet (214 meters).

(B): For all other airplanes--1,000 feet (305 meters).

(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--689 feet (210 meters).

(B): For airplanes with three engines--853 feet (260 meters).

(C) For airplanes with fewer than three engines--984 feet (300 meters).

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 EPNLr 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 dB-down 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: FAA 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: FAA-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)

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 August 7, 2002, 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 V2+10kt (V2+19km/h) but may not be greater than V2+20kt (V2+37km/h). This speed must be attained as soon as practicable after lift-off and be maintained throughout the takeoff noise certification test. For Concorde airplanes, the test day speeds and the acoustic day reference speed are the minimum approved value of V2 +35 knots, or the all-engines-operating speed at 35 feet, whichever speed is greater as determined under the regulations constituting the type certification basis of the airplane; this reference speed may not exceed 250 knots. 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

(1) Supersonic Airplanes: This AC does not address the noise certification requirements for supersonic transport category airplanes, other than Concorde (See section 1d).

c. Procedures

(1) V2 Takeoff Airspeed: Criteria for determining V2 takeoff airspeeds are specified in 14 CFR Part 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 FAA.

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 FAA 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 FAA 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} + 10 kts (V_{REF} + 19 km/h) 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. For Concorde airplanes, a steady approach speed that is either the landing reference speed + 10 knots or the speed used in establishing the approved landing distance under the airworthiness regulations constituting the type certification basis of the airplane, whichever speed is greater. 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 FAA.

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 FAA observer, or appropriately delegated designee, must witness airplane noise certification tests to ensure compliance with a FAA 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 FAA 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 FAA. 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 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 ±3 kt (±5.5 km/h) of the average airspeed over the 10 dB-down points, and is determined by the FAA 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]

XV. 14 CFR PART 36 APPENDIX F. FLYOVER NOISE REQUIREMENTS FOR PROPELLER - DRIVEN SMALL AIRPLANE AND PROPELLER-DRIVEN, COMMUTER CATEGORY AIRPLANE CERTIFICATION TESTS PRIOR TO DECEMBER 22, 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]

XVI. 14 CFR PART 36 APPENDIX G. TAKE-OFF NOISE REQUIREMENTS FOR PROPELLER-DRIVEN, SMALL AIRPLANE AND PROPELLER-DRIVEN, COMMUTER CATEGORY AIRPLANE CERTIFICATION TESTS ON OR AFTER DECEMBER 22, 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 propeller-driven, commuter category airplanes specified in Secs. 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 50 feet from the microphone, an object must be no taller than 13.4 feet above the ground at the microphone location in order to meet this requirement. At a distance of 25 feet from the microphone, an object on the ground must be no taller than 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 50 feet.

379. Section G36.101(b)

The tests must be carried out under the following conditions:

(1) No precipitation;

(2) Ambient air temperature between 36 and 95 degrees F (2.2 and 35 degrees C);

(3) Relative humidity between 20 percent and 95 percent, inclusively;

(4) Wind speed may not exceed 10 knots (19 km/h) and cross wind may not exceed 5 knots (9 km/h), 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 [noise] is recorded at the required measuring point, and

(6) The meteorological measurements must be made between 4 ft. (1.2 m) and 33 ft. (10 m) above ground level. If the measurement site is within 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 4 feet (1.2 meters) and 33 feet (10 meters) 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 propeller-driven 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)

The flight test procedures, measuring equipment, and noise measurement procedures must be approved by the FAA.

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 FAA. 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 FAA 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 14 Code of Federal Regulations (CFR) 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) FAA 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 the FAA on its own merits. The FAA Office of Environment and Energy (AEE) 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)

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 FAA 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)

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-mean-square (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 root-mean-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 FAA - 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)

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 the FAA Local Aircraft Certification Office (ACO) certifying authority.

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 FAA 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

At the time of preparation of this Advisory Circular (AC), International Electrotechnical Commision (IEC) 651 Publication has been replaced by IEC 61672-1, and IEC 561 has been replaced by IEC 61265.

c. Procedure

(1) Approval of Equipment: FAA 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)

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 low-frequency 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 A-weighting 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 pre-

emphasis, 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 one-third 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 FAA. In addition, use of a pre-emphasis / 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)

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 14 CFR 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 14 CFR 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 FAA 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)

The equipment must be acoustically calibrated using facilities for acoustic free-field calibration and if the Administrator requests analysis of the tape recording, the analysis equipment shall be electronically calibrated by a method approved by the FAA. Calibrations shall be performed, as appropriate, in accordance with paragraph A36.3(e) 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 A36.3.9.8. 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 FAA 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 5 knots (9 km/hr).

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.

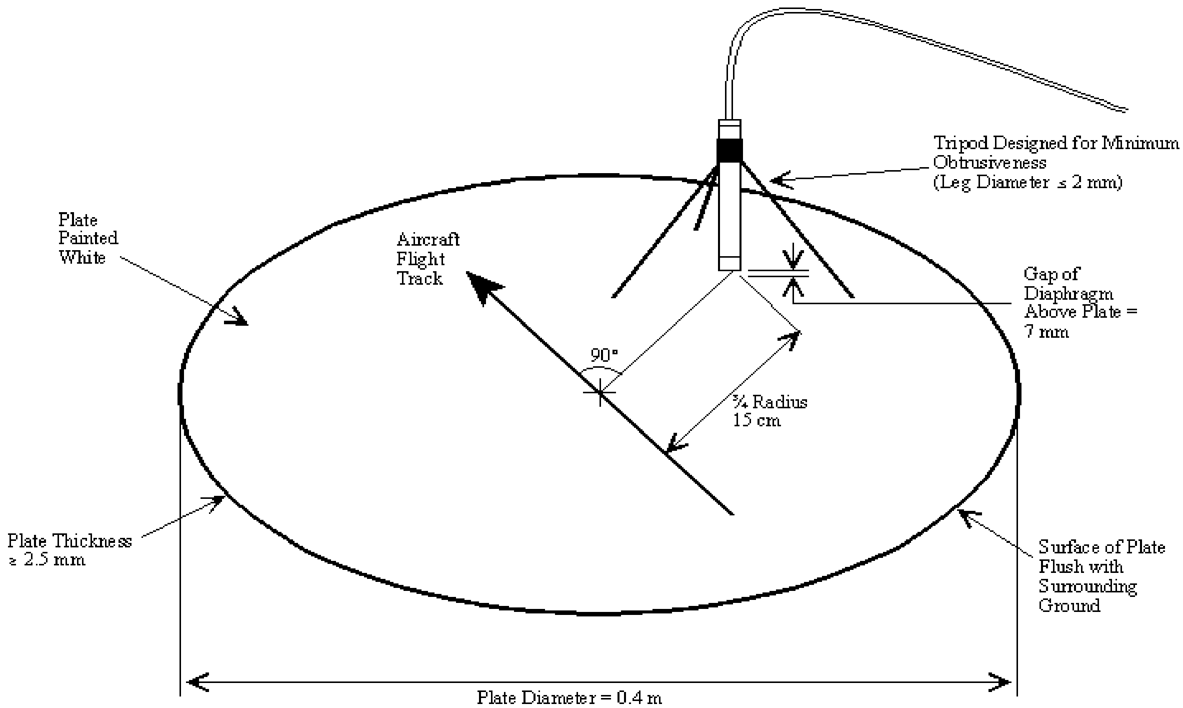


Figure 13 **Configuration for ½ in. Inverted Microphone Over Plate**

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 AEE approval has been obtained.

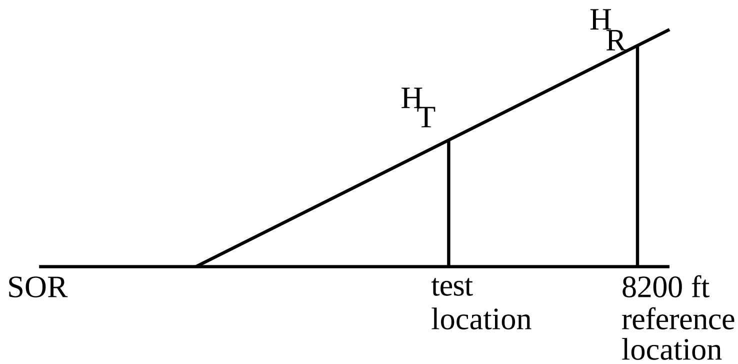


Figure 14 - Adjusted Measurement Location (method is intended for high-performance airplanes)

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.

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 FAA 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

(1) 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.

a. 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.

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. 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

(1) 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

(1) 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 FAA 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.

400. Section G36.111 Flight procedures

(a) The noise measurement point is on the extended centerline of the runway at a distance of 8200-ft (2500 m) 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 (Vy) ±5 knots (±9 km/hour) indicated airspeed. All test, measurement, and data correction procedures must be approved by the FAA.

a. Explanation

This regulation identifies the overhead flight position (height and lateral position) of the airplane during noise certification testing. The FAA-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 Vy 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 8,200 feet (2,500 m) 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 mb (013.25 hPa);
(2) Ambient air temperature of 59 deg. F (15 deg.C);
(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 FAA approved.

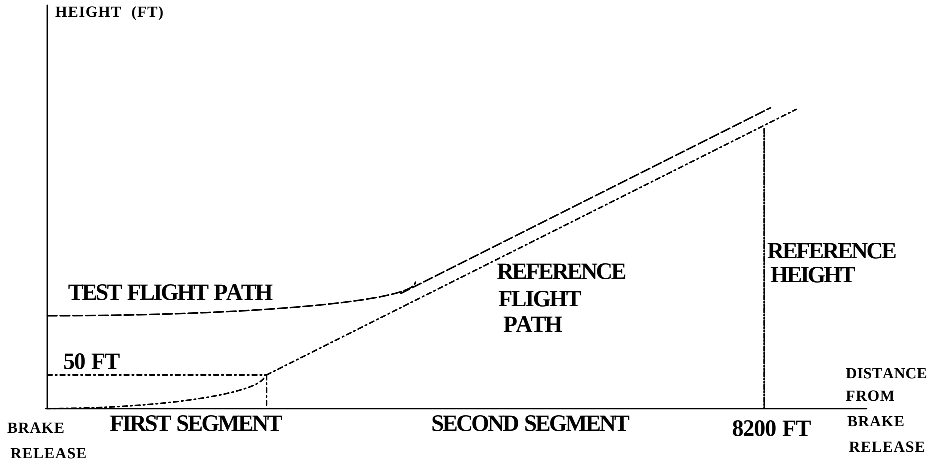


Figure 15: Typical Test and Reference Flight Paths

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

(1) Any information used in these calculations is to be FAA 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 50-ft (15m) 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 take-off 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 rates of climb (Vy).

(iv) Maximum continuous installed power and rpm for variable pitch propeller(s) shall be used. For fixed pitch propeller(s), the maximum power and rpm that can be delivered by the engine(s) must be maintained throughout the second segment.

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 (Vy) 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 59 F and 70 percent relative humidity by a FAA approved method.

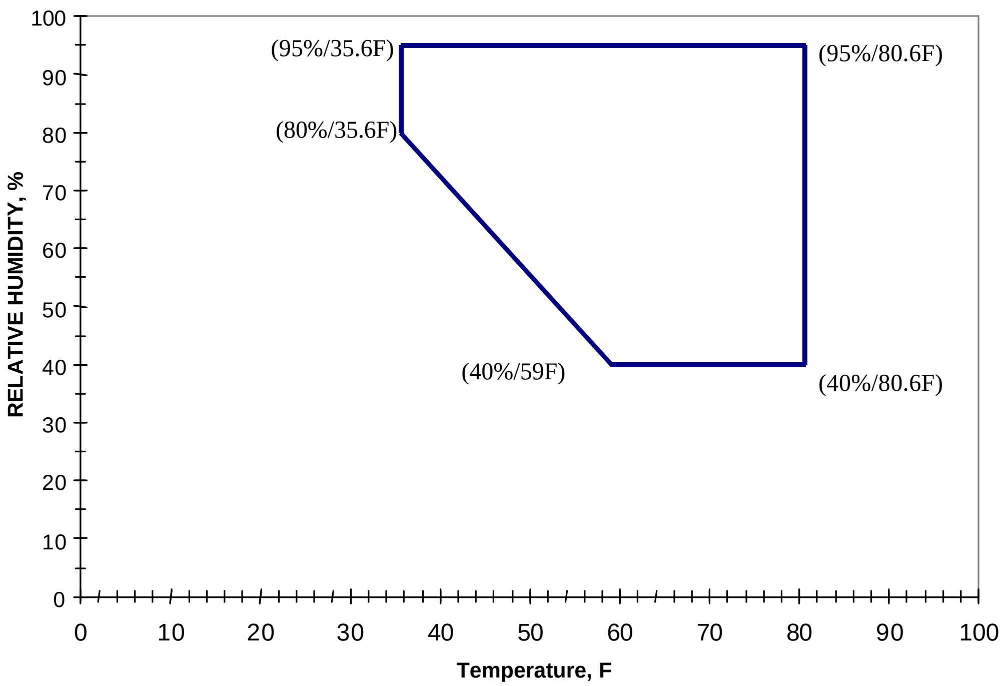


Figure 16: MEASUREMENT WINDOW FOR NO ABSORPTION CORRECTION
(Figure G1 of regulation)

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 77°F, 25°C. Reference airplane performance is obtained for an air temperature of 59°F. This inconsistency between the acoustic and airplane performance reference conditions was corrected by adapting 59°F for both reference conditions.

409. Section G36.201(c)

Helical tip Mach number and power corrections must be made as follows:
(1) Helical tip Mach number and power corrections must be made if --
(i) The propeller is a variable pitch type; or
(ii) The propeller is a fixed pitch type and the test power is not within 5 percent of the reference power.
(2) No corrections for helical tip Mach number variation need to be made if the propeller helical tip Mach number is:
(i) At or below 0.70 and the test helical tip Mach number is within 0.014 of the reference helical tip Mach number.
(ii) 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.
(iii) 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

For a variable-pitch propeller, adjustments are required for both helical tip Mach number and engine power. For a fixed-pitch propeller, helical tip Mach number and engine power adjustments are not required if the test power is within 5 percent of the reference.

ICAO Annex 16 Chapter 10 requires that the tip Mach number and power adjustments for both variable-pitch and fixed-pitch propellers be applied to the measured data regardless of engine power. This is an unharmonized item.

b. Supplemental Information

(1) Engine Power: Engine power depends on the atmospheric conditions, specifically, pressure altitude and air temperature. The test day conditions are likely to be different from the reference conditions, so the test engine power may not be the same as the reference engine power. Manufacturer's approved airworthiness information can be used to determine engine power for test conditions and reference conditions.

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.

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 α - 0.7 H_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

Delta (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 FAA approval.

b. 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 14 CFR Part 36, reproduced as Figure 16 in this AC.

Conditions that would be outside the measurement window include–

(i) Temperatures in excess of 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 35.6°F
(iv) Combinations of temperature and Relative Humidity with values below the line in Figure 16 that connects 80 percent Relative Humidity, 35.6°F and 40 percent Relative Humidity, 59°F.

In general the correction, Delta (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 α - 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 α 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 α 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.

RATE OF ATMOSPHERIC ABSORPTION

Temp : AIR TEMPERATURE, DEGREES F
α : ATMOSPHERIC ABSORPTION COEFFICIENT, ALPHA, dB/1000 FT

500 Hz GEOMETRIC MEAN FREQUENCY
AND 70 PERCENT RELATIVE HUMIDITY

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

Table 5: Rate of Atmospheric Absorption (a) at 500 Hz Frequency

412. Section G36.201(d)(2)

Measured sound levels in decibels must be corrected for height by algebraically adding an increment equal to Delta (1). When test day conditions are within those specified in figure G1:

Delta (1) = 22 log (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) = 20 log (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) = k log (M_R/M_T)

where M_T and M_R are the test and reference helical tip Mach numbers, respectively. The constant "k" 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 may be determined from approved data. A nominal value of k = 150 may be used when M_T is smaller than M_R. No correction may be made using the nominal value of k 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, and 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 (M_R). 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.

(ii) The speed at which the propeller tip is rotating (e.g., in ft/sec), denoted V_{tip}
(iii) 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 V_{tip}, V_{tas}, and c for the appropriate conditions is as follows:

V_{tip} = rpm x D x π / 60, ft/sec

where rpm is that of the propeller, D is the propeller diameter in feet, and π = 3.14159

V_{cas} = airplane calibrated air speed multiplied by 1 to convert from knots to ft/sec

$$V_{tas} = \frac{V_{cas}}{\sqrt{s}}$$

where $s = \frac{\Delta}{q}$

Pressure Ratio $\Delta = \left(1 - \left(6.8753E^{-6}h\right)^{5.2561}\right)$

where h is pressure altitude in feet

Temperature Ratio $q = \frac{(T + 459.67)}{(59 + 459.67)}$, 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 - lapse rate x 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.

$M_R = V_{hel}/c$ day at 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 ***log*** (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 Delta (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 Vy (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 x H_R, 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:

$$P_T = P_K\left[\left(\frac{T_K}{T_T}\right)^{\frac{1}{2}}\right]\left[\frac{(s - 0.117)}{0.883}\right]$$, for normally aspirated engines, and

$$P_T = P_K\left[\left(\frac{T_K}{T_T}\right)^{\frac{1}{2}}\right]$$, for turbocharged engines

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 σ 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 in-flight 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 FAA 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

The measuring point must be overflown at least six times. The test results must produce an average noise level (Lamax) 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 the omission is approved by the FAA.

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:

$$\left(LA_{\max}\right)_{avg} = \frac{1}{N}\sum_{i=1}^{n} LA_{\max(i)} = \frac{1}{N}\left[LA_{\max(1)} + LA_{\max(2)} \ldots . LA_{\max(n)}\right]$$

where $LA_{max(i)}$ is the corrected noise level of the i^{th}, 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 $(LA_{max})_{avg}$ 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.

$$s = \sqrt{\frac{1}{(\mathrm{N}-1)} \sum_{i=1}^{\mathrm{N}} \left(LA_{\max} - (LA_{\max})_{avg}\right)^2}$$

$$= \sqrt{\frac{1}{(\mathrm{N}-1)} \sum_{i=1}^{\mathrm{N}} \left(x_i - \bar{x}\right)^2}$$

where

$X_i = LA_{\max(i)}$ = the corrected noise level, in dB (A) of the i^{th} valid test flight

$\bar{x} = (LA_{\max})_{avg}$ = 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:

$$\text{CI (confidence interval)} = \pm t \frac{S}{\sqrt{\mathrm{N}}}$$

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

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

Table 6: Student's t Distribution For 90 Percent Confidence Interval

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) The noise level must not exceed 76 dB (A) up to and including aircraft weights of 1,320 pounds (600 kg). For aircraft weights greater than 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 19,000 pounds (8,618 kg). Figure G2 shows noise level limits vs. airplane weight.

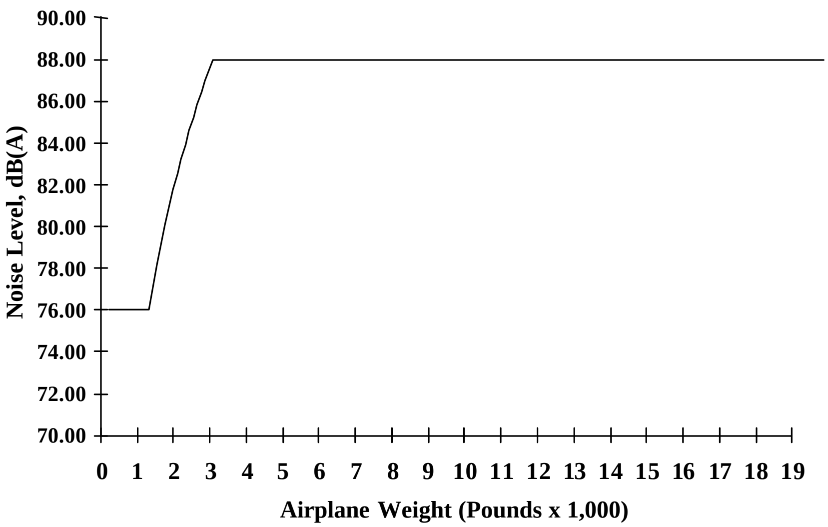


Figure 17 - Noise Level vs. Airplane Weight (Figure G2 of part 36, Appendix G)

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: The form of the weight/limit relationship is logarithmic in nature between airplane weights of 1,320 pounds and 3,086 pounds. This format differs from that used to determine the noise level limits for other aircraft under 14 CFR Part 36.

W = Maximum takeoff weight in pounds

	0	1320	3086	19000
Noise level in dB (A)	76	32.67 log W – 26.0	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]

XVII. 14 CFR PART 36 APPENDIX H- NOISE REQUIREMENTS FOR HELICOPTERS UNDER SUBPART H [To be completed later]

[To be completed later]

XVIII. 14 CFR PART 36 APPENDIX J- ALTERNATIVE NOISE CERTIFICATION PROCEDURE FOR HELICOPTERS UNDER SUBPART H HAVING A MAXIMUM CERTIFICATED TAKE-OFF WEIGHT OF NOT MORE THAN 6,000 POUNDS [To be completed later]

[To be completed later]