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# AMERICAN NATIONAL STANDARD

## **Methods for the Measurement of Noise Emissions from High Performance Military Jet Aircraft**

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ANSI/ASA S12.75-2012

Accredited Standards Committee S12, Noise

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Standards Secretariat  
Acoustical Society of America  
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AMERICAN NATIONAL STANDARD

**Methods for the Measurement of Noise Emissions  
from High Performance Military Jet Aircraft**

**Secretariat:**

**Acoustical Society of America**

**Approved on September 20, 2012 by:**

**American National Standards Institute, Inc.**

**Abstract**

This standard describes noise measurement procedures to characterize the noise emissions from high performance (supersonic jet flow) military aircraft. Specific detailed noise measurement procedures are described for characterizing noise for environmental documents such as environmental impact statements and environmental assessments, and for quantifying aircraft noise emissions. This standard describes test procedures for ground run-up and flyover tests for conventional take-off and landing, short/vertical take-off and landing operations. The standard also describes signal processing, data formatting, and measurement uncertainty.

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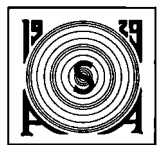
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## Foreword

*[This Foreword is for information only, and is not a part of the American National Standard ANSI/ASA S12.75-2012 American National Standard Methods for the Measurement of Noise Emissions from High Performance Military Jet Aircraft. As such, this Foreword may contain material that has not been subjected to public review or a consensus process. In addition, it does not contain requirements necessary for conformation to the standard.]*

This standard comprises a part of a group of definitions, standards, and specifications for use in noise. It was developed and approved by Accredited Standards Committee S12 Noise, under its approved operating procedures. Those procedures have been accredited by the American National Standards Institute (ANSI). The Scope of Accredited Standards Committee S12 is as follows:

*Standards, specifications, and terminology in the field of acoustical noise pertaining to methods of measurement, evaluation, and control, including biological safety, tolerance, and comfort, and physical acoustics as related to environmental and occupational noise.*

This standard is not comparable to any existing ISO Standard.

At the time this Standard was submitted to Accredited Standards Committee S12, Noise for approval, the membership was as follows:

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\*When preparation of this standard was ongoing, John (Jack) M. Seiner (now deceased) was part of the working group. His efforts and expertise were carried forward and are acknowledged by the publication of this standard.

Suggestions for improvements of this standard will be welcomed. They should be sent to Accredited Standards Committee S12, Noise, in care of the Standards Secretariat of the Acoustical Society of America, 35 Pinelawn Road, Suite 114E, Melville, New York 11747-3177. Telephone: 631-390-0215; FAX: 631-390-0217; E-mail: [asastds@aip.org](mailto:asastds@aip.org).

## Introduction

Noise from high performance military aircraft (supersonic jet flow exhaust) can impact the hearing and performance of personnel working near these aircraft and can be a source of annoyance to people living near airbases, airports, and ranges where these aircraft are operated. Federal agencies operating airfields are required to analyze the noise impacts by proposed new flying operations as part of the environmental analysis that is required by the National Environmental Policy Act of 1969 (NEPA). Additionally, overexposure of flight line/flight deck personnel to high levels/durations of noise can adversely affect hearing and negatively impact voice communication capability.

Accurate, reliable, and repeatable noise measures from standardized noise measurement techniques will help ensure confidence in the data used in the modeling and prediction of noise impacts. Accurate, reliable, and repeatable noise measurements are also required to compute noise exposures and associated hearing damage risk of personnel working near these aircraft. Such data are also essential for evaluation of voice communication capabilities. Finally, these measures are needed to assess noise produced by aircraft systems.

This standard describes several methods for collecting noise data from high performance military aircraft. Each method has a specific application and therefore it would be extremely rare where all the methods were applied simultaneously. The following table outlines the general methods described in this standard. Normally, individual test methods would be cited in regulations or contract specification.

| Aircraft performance measurement methods |                                                                                                                |
|------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Ground run-up                            | CTOL (Conventional Take-Off and Landing)<br>Personnel near-field                                               |
|                                          | CTOL<br>Noise reduction studies near-field                                                                     |
|                                          | CTOL<br>Far-field community noise                                                                              |
|                                          | CTOL<br>Far-field propagation/noise reduction studies                                                          |
|                                          | STO/VL, VTO/VL (Short Take-Off/Vertical Landing), (Vertical Take-Off/Vertical Landing)<br>Personnel near-field |
| Flyover                                  | CTOL                                                                                                           |
|                                          | STO/SL (Short Take-Off/Short Landing)                                                                          |
|                                          | VTO/VL                                                                                                         |

Collecting noise measurements from high performance military aircraft is an undertaking that involves much preparation and responsible decision making. This standard was developed over a series of working group meetings and a workshop that formed consensus defining measurement methods that would result in accurate, reliable, and repeatable noise data. The standard addresses several important parameters such as microphone height and location, acoustic instrumentation, measurement site specifications, weather measurement and weather limits, data analysis, standard data formatting and organization, and data reporting.

The methods described in this standard are more extensive than measurement techniques previously used for collecting noise measurements from high performance military jet aircraft. Limitations in instrumentation, test location, weather, cost, and schedule may drive decisions for non-compliance with portions of this standard. However, the methods described in this standard are necessary to fully characterize and quantify the noise produced by high performance military aircraft. The methods in this standard use arrays of microphones to characterize both the level and directivity of noise generated by the aircraft. Many aircraft noise emission measurements will typically utilize only one or two of the specific measurement methods/microphone arrays described in this standard.

Microphone height and location are two of the parameters which vary based on the objectives for the measurement and the selected measurement method. For example, in the method for measuring near-field noise for the assessment of personnel noise exposure, microphone heights of 3 and 5 feet above ground level are selected to represent a human kneeling or standing around the aircraft while for near-field noise reduction measurements ground microphones are selected to give spectral information without the interference from ground reflections. Similarly, microphone locations and number vary with the different methods. For example, in the method for measuring near-field noise for defining personnel noise, microphone locations are defined at 30 feet and 42 feet lines parallel with the center of the aircraft (based on “final checker” locations and aircraft carrier “foul line” locations) and two arcs at 50 feet and 125 feet to bound the rest of the near-field locations.

Microphone height and locations for flyover noise measurements were defined to give accurate level information with minimal interference from ground reflections and micro-climate effects very near the ground. Methods define microphone heights ranging from ground level to 30 feet above ground on tripods from 300 to 1200 feet above ground suspended from towers or cranes. The microphone locations for flyover measurements are arranged to collect data for source modeling, source model validation, source linear and non-linear propagation, and propagation model validation.

Measurement site requirements are defined to reduce as much as possible the confounding of measured data by irregularities of the measurement site including acoustic reflections from buildings and other structures. Weather requirements are defined to reduce the adverse effects of wind, turbulence, and other atmospheric conditions which make accurate, repeatable, and reliable measurements difficult.

Regardless of the method chosen to collect noise measurements from high performance military aircraft, this document importantly standardizes the analysis, organization, and reporting of the data. A format has been created to ease the organization and exchange of data which has proved to be difficult in the past.

## American National Standard

# Methods for the Measurement of Noise Emissions from High Performance Military Jet Aircraft

## 1 Scope

This standard describes noise measurement procedures to characterize the noise emissions, including directivity and non-linearity, from high performance military (supersonic jet flow) aircraft during ground and airborne operations. The data resulting from the procedures described in clauses 6.3 through 6.7 of this standard are appropriate as input for community noise propagation models such as NOISEMAP[12] and the Advanced Acoustic Model (AAM)[16]. NOISEMAP data have been converted and applied for use in the Federal Aviation Administration's Integrated Noise Model (INM)[7] to supplement community noise assessments.[24] These models will use the noise measurements collected in accordance with this standard for preparation of official documents such as community environmental impact statements and environmental assessments. Noise measurements collected in accordance with this standard will also be used to define aircraft support personnel noise exposures, aircraft noise reduction and propagation studies, and evaluation of aircraft and propulsion system compliance with noise requirements and regulations.

This standard describes methods for the measurement of noise from high performance military aircraft covering the following operation modes: ground run-up, flyover, conventional take-off and landing and short/vertical take-off and landing. This standard serves as a toolbox of recommended measurement locations and acquisition methods for specific types of test and non-test applications. There are separate methods for measuring personnel noise exposure (e.g., Figure 2), ground run-up (e.g., Figure 4), and flyover noise (e.g., Figure 7) for use in National Environmental Policy Act (NEPA) documents such as environmental impact statements, and for development uses such as measuring/validating the propagation of sound from a source or the effect of a noise reduction technology (e.g., Figures 3, 5, 8). These measurement methods can be conducted independently, or, in some instances, combined, to satisfy multiple goals and thus potentially minimize cost and test time. It is not required that all methods in this standard are employed to characterize the noise emitted from an aircraft. In some circumstances both ground run-up and flyover measurements will have to be used in combination to predict far-field noise levels from aircraft operations; however, they cannot be used interchangeably if accurate noise level exposure predictions are desired.

The data recording and reporting requirements are given in order to ensure compatibility with common noise exposure mapping tools. Noise measurement and signal processing procedures are defined in order to achieve accuracy within the defined measurement uncertainty.

This standard does not address the application of noise propagation models such as NOISEMAP, INM, or AAM in the NEPA-defined environmental processes. The results of the noise measurements conducted in accordance with this standard are limited to the characterization of noise emissions of high performance military aircraft. Additionally, this standard applies only to future measurements conducted after approval by ANSI. It is not intended to require the retest or re-measurement of aircraft noise measured prior to the publishing date of this standard.

## 2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI S1.1-1994 (R2004) *American National Standard Acoustical Terminology*

ANSI S1.4-1983 (R2006)/ANSI S1.4a-1985 (R2006) *American National Standard Specification for Sound Level Meters*

ANSI/ASA S1.6-1984 (R2011) *American National Standard Preferred Frequencies, Frequency Levels, and Band Numbers for Acoustical Measurements*

ANSI/ASA S1.8-1989 (R2011) *American National Standard Reference Quantities for Acoustical Levels*

ANSI/ASA S1.11-2004 (R2009) *American National Standard Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters*

ANSI/ASA S1.13-2005 (R2010) *American National Standard Measurement of Sound Pressure Levels in Air*

ANSI/ASA S1.15-1997 (R2011) *American National Standard for Measurement Microphones – Part 1: Specifications for Laboratory Standard Microphones*

ANSI S1.17-2004/Part 1 *American National Standard Microphone Windscreens-Part 1: Measurements and Specifications of Insertion Loss in Still or Slightly Moving Air*

ANSI/ASA S1.18-2010 *American National Standard Method for Determining the Acoustic Impedance of Ground Surfaces*

ANSI/ASA S1.26-1995 (R2009) *American National Standard Method for Calculation of the Absorption of Sound by the Atmosphere*

ANSI/ASA S1.40-2006 (R2011) *American National Standard Specifications and Verification Procedures for Sound Calibrators*

ANSI/ASA S1.42-2001 (R2011) *American National Standard Design Response of Weighting Networks for Acoustical Measurements*

Federal Aviation Administration Noise Standards. Title 14, Code of Federal Regulations, Chap. 1, Part 36, 34 Fed. Reg. 1864, November 1969, as amended.

ISO/IEC Guide 98 *Uncertainty of measurement*

### 3 Terms and definitions

For the purposes of this standard, the terms and definitions given in ANSI S1.1 and the following apply:

**3.1 acoustic far-field.** The distance after which the noise field approximates that of a compact acoustic source (typically greater than 500 feet for an engine with supersonic jet flow). See ISO 3745-1977 definition 3.10.

**3.2 acoustic near-field.** The distances within which the noise field cannot be considered to be radiated by a compact source.

**3.3 aircraft centerline.** The longitudinal axis through the geometric center of the aircraft.

**3.4 atmospheric absorption.** Reduction of sound level due to various attenuation factors such as molecular relaxation and thermoviscous effects.

- 3.5 attitude (of an aircraft).** The orientation of the aircraft in degrees relative to the horizon in roll and pitch.
- 3.6 axisymmetric nozzle.** A nozzle that is symmetric about the engine's longitudinal axis; i.e., a round or circular nozzle.
- 3.7 configured for landing.** Aircraft with lift-enhancing devices such as flaps and leading edge slats and landing gear extended in preparation for landing.
- 3.8 directivity (of a microphone).** Spectral and amplitude behavior, as a function of angle, from the direction normal to the diaphragm of the microphone.
- 3.9 directivity (of the source).** Spectral and amplitude behavior, as a function of angle, from the centerline axis of the aircraft.
- 3.10 engine inlet.** Part of the aircraft/airframe forward/upstream of the compressor section of the engine that provides airflow to the engine.
- 3.11 engine inlet plane.** Plane through the centroid of the inlet and perpendicular to the aircraft centerline.
- 3.12 engine thrust request (ETR).** Throttle setting for aircraft using digital engine control usually represented as a percentage of a reference thrust condition.
- 3.13 flight path.** Trajectory of the air vehicle. The curve defined by the tangent of the velocity vector of the aircraft as a function of time.
- 3.14 free-field microphone.** A microphone designed for use in measuring normally incident sound fields.
- 3.15 geometric far-field.** Distances greater than 100 nozzle diameters from the nozzle plane. Typically distances greater than 250 feet.
- 3.16 geometric near-field.** Distances less than 100 nozzle diameters from the nozzle plane. Typically distances less than 250 feet and encompassing personnel noise exposure locations.
- 3.17 grazing incidence.** The microphone oriented so that the sound wave propagation direction is parallel to the microphone diaphragm; i.e., 90° incidence angle.
- 3.18 ground impedance.** The specific acoustic impedance of the ground within the measurement area.
- 3.19 ground track.** Projection of the flight path onto the ground.
- 3.20 lateral attenuation.** Attenuation, not attributed to atmospheric absorption or wave divergence (geometric spreading), of sound propagating from an aircraft sound source to a receiver at a location to the side of the flight path.[28]
- 3.21 maximum radiation angle.** The angle of maximum overall sound pressure level (OASPL) relative to the thrust angle.
- 3.22 microphone array reference point (MARP).** The origin of the microphone array relative to the intersection of the nozzle plane with the ground on the aircraft centerline.

**3.23 military power (MIL power).** The maximum (100%), non-augmented/non-afterburning, rated thrust of the jet engine.

**3.24 noise.** Unwanted or undesired sound.

**3.25 nonlinear acoustic propagation.** Propagation when the wave speed depends on the wave amplitude as well as the local speed of sound.

**3.26 normal incidence.** The microphone oriented so that the sound wave propagation direction is perpendicular to the microphone diaphragm, i.e., 0° incidence angle.

**3.27 nozzle diameter.** Diameter of the nozzle at the nozzle plane. For non-axisymmetric nozzles, the diameter of the equivalent circle with the same area.

**3.28 nozzle plane.** Plane through the outer or aft-most tips of the nozzle.

**3.29 point source.** A source that radiates sound as if from a single point.

**3.30 pressure microphone.** A microphone that responds to sound pressure.

NOTE A pressure microphone has a sensitivity that increases with frequency due to reflection at the microphone diaphragm, which causes a pressure increase. The effect is due solely to the geometry of the microphone and occurs when sound wavelengths are short compared with the diameter of the microphone.

**3.31 protection grid.** An integral protective cage of plastic, metal or wire mesh used to protect the microphone diaphragm from inadvertent contact and physical damage (also known as grid cap).

**3.32 random incidence microphone.** Omnidirectional microphone having essentially a constant sensitivity as a function of frequency over a specified frequency range for free-field sound waves that are successively incident on the microphone from essentially all directions with equal probability.

NOTE 1 The frequency response of a random-incidence microphone is similar to that of a true pressure microphone; see 3.30 (pressure microphone).

NOTE 2 Random-incidence response is essentially equal to diffuse-field response where sound waves impinge on a microphone more-or-less simultaneously with equal probability from all directions.

**3.33 specific acoustic impedance.** Ratio of the surface pressure to average particle velocity directed into the ground at the surface or at a point in a sound field, quotient of sound pressure by particle velocity. Unit, pascal – second per meter [Pa s/m].

See ANSI/ASA S1.18-2010.

**3.34 spectrum.** The distribution of energy as a function of frequency for a particular sound.

**3.35 standard acoustic day.** 59° Fahrenheit (15° C) and 70 % relative humidity.

**3.36 thrust angle.** The relative angles (pitch and yaw) between the thrust axis and the aircraft centerline where the direction of the nose of the aircraft is 0°.

**3.37 windscreen.** A removable protective covering of foam, plastic, fabric, or wire mesh held at a distance from the microphone diaphragm used to reduce effects of wind. The windscreen is used in addition to the integral microphone protection grid.

## 4 Noise measurement instrumentation requirements

### 4.1 Noise recording systems

The recording system shall be a digital recording system with associated microphones, pre-amplifiers, cables, and amplifiers with the following characteristics.

### 4.2 Microphones and preamplifiers

#### 4.2.1 Specifications

All microphones shall meet or exceed the requirements of ANSI/ASA S1.15-1997 (R 2011), for Type 1 from 4 Hz to 11.5 kHz. The sensitivity, bandwidth, maximum sound pressure level (SPL) capability, and noise floor characteristics of all microphones shall be described; be appropriate for the measurement location, frequency range, and acoustic levels; and shall be in accordance with 4.3.1 signal-to-noise ratio and 4.3.3 signal measurement peak handling of this standard.

#### 4.2.2 Microphone height and orientation

Four different heights of microphones and orientations are used in this standard. Ground microphones inverted over a hard surface, microphones at 3 feet above ground, microphones at 5 feet above ground, and microphones at 30 feet above ground are used in the described methods. Each of the methods also describes the specific orientation of the microphones. Additionally, the flyover noise measurement procedure includes options for microphones on towers or cranes from the surface up to 1250 feet above ground (which would provide a 45° upper elevation angle for an aircraft flying at 250 feet above ground level [AGL]).

#### 4.2.3 Frequency response laboratory calibration

All microphones shall be calibrated for frequency response from a minimum of 4 Hz to 11.5 kHz or the maximum frequency range every 18 months for pre-polarized microphones and every 12 months for condenser microphones. Microphone calibrations shall be reported at both normal and grazing incidence. All preamplifiers shall be calibrated on the same schedule as the associated microphone. Calibration procedures shall be traceable to National Institute of Standards and Technology (NIST). The most recent calibration data shall be recorded and reported with each field measurement. Before each field test, microphones should be tested to ensure their sensitivity is within  $\pm 6\%$  (which would correspond to a  $\pm 0.5$  dB change in SPL relative to the stated sensitivity). If a microphone's sensitivity is found to vary more than 6%, then a complete calibration shall be required before the microphone should be used.

#### 4.2.4 Windscreens

Windscreens shall meet the requirements of ANSI S1.17-2004/Part 1.

### 4.3 Recorder general requirements

#### 4.3.1 Signal-to-noise ratio

An individual test point at a specific 1/3-octave band shall be discarded for individual microphones if the signal-to-noise ratio (SNR) at that 1/3-octave band of the microphone is less than 10 dB. The SNR ratio is an important part of the measurement standard uncertainty. For minimum SNRs of 16 dB the uncertainty is 0.1 dB, for 13 dB SNR uncertainty is 0.2 dB, and for 10 dB SNR the uncertainty is 0.4 dB.

#### 4.3.2 Cross talk

The maximum digitally recorded cross talk measured at 1 kHz between adjacent channels shall be no more than -70 dB.

#### 4.3.3 Signal measurement peak handling

The peak signal handling capacity of the signal measurement chain shall be at least 12 dB above the root-mean-square (rms) level of the overall maximum sound pressure level to prevent clipping.

#### 4.3.4 Timing

All measurements including those from the aircraft shall be taken synchronously with the same time reference. The timing reference shall be noted appropriately. All data shall be reported with the test clock time.

#### 4.3.5 Central recording systems

The data recording system(s) shall have a per-channel bandwidth of not less than 5 Hz to 20 kHz, shall sample a minimum of 96,000 samples per second, shall have a minimum of 16 bit resolution, and shall be linear within  $\pm 0.5$  dB over the reported measurement range (i.e., the minimum sound pressure level recorded and reported to the maximum sound pressure level recorded and reported).

#### 4.3.6 Remote stations

For microphone locations at distances greater than or equal to 2000 feet, the data recording system(s) shall have a per-channel bandwidth of not less than 20 Hz to 11.4 kHz, shall sample a minimum of 48,000 samples per second, shall have a minimum of 16 bit resolution, and shall be linear within  $\pm 1.0$  dB over the reported measurement range (i.e., the minimum sound pressure level recorded and reported to the maximum sound pressure level recorded and reported).

#### 4.3.7 Portable handheld system

Personnel-mounted systems, consisting of a recorder, a power supply, and a handheld microphone, or handheld Type 1 precision sound level meter meeting the requirements of ANSI S1.4-1983 (R2006) and ANSI S1.4a-1985 (R2006) with 1/3-octave band or octave-band capability are used to record and measure noise spectra in locations around the aircraft. Determination of the location of the microphones during the measurement period is critical. A Differential Global Positioning System (DGPS) or other similarly accurate tracking instrumentation may be used to record the location and time of the recording system. Video cameras may also be used if the time on the camera is synchronized with the recording system.

**NOTE** Near-field specific and defined personnel locations shall be selected and defined based on generally used locations during routine and special maintenance, engine run-up for pre-flight checks, and all other actions around the aircraft.

#### 4.3.8 Weather instrumentation

Temperature, humidity, ambient pressure, and wind velocity (speed and direction) shall be recorded at the measurement site. At least one location, in the vicinity of the microphones, is required. A real time display is required so that conditions can be observed and testing can be halted if conditions are outside wind, temperature or humidity limits. The weather data shall be recorded at a minimum of one sample per second at the measurement site with time synchronization. The wind direction reference shall be specified. Additionally, the temperature and wind speed profile shall be recorded at several heights from

the surface to twice the maximum flight test altitude for flyover noise measurements. For ground run-up measurements, the temperature and wind profile up to 1000 feet AGL shall be estimated from simultaneous measurements at 0.5, 5, 10, and 30 feet within a 30-foot radius ground circle of the one fixed weather measurement location in the vicinity of the microphones or from direct measurements. If local conditions suggest that micrometeorology can vary across the measurement site, weather data should be collected at additional locations, especially if ground microphones are being used.

**NOTE** A simple linear temperature profile and a logarithmic wind speed profile can be used to estimate the temperature and wind profile up to 1000 feet AGL. The temperature can be defined as  $T=B*z$  where  $B$  is a proportional constant and  $z$  is the height of the measurement. The wind speed can be defined as  $u=A*\ln(z/z_0)$  where  $A$  is a proportional constant,  $z$  is the height of interest, and  $z_0$  is called the roughness length (a function of the surface, typically 0.03 meters for flat, grassy terrain). The wind speed can be calculated anywhere once  $A$  is computed.

#### 4.3.9 Calibration

The weather measurement instrumentation shall be calibrated for temperature and wind speed according to the manufacturer's recommendation, prior to the measurement. The results of the calibration shall be reported with the measurement data set. Additionally, a field check on the wind speed shall be conducted on each day of the test comparing the results of wind speed measured using the weather instrumentation and a separate independent wind speed measuring device. The difference in wind speed shall be less than 2 knots.

## 5 Measurement site

### 5.1 Terrain

#### 5.1.1 General requirements

The terrain requirements are specified relative to specific test methods. Deviations from the requirements of this standard will result in increased uncertainty of the measured data and shall be documented in the test report. Deviations from 5.1.2, 5.1.3, and 5.1.4 shall be measured using the procedures described in Annex E. However, these measurements are not a substitute for compliance with the requirements but only provide information relative to the contamination of the data by acoustic reflections and obstructions. No measurements shall be made when the terrain is covered by snow or standing water. Locations for measuring noise from an aircraft shall 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. The test site terrain shall permit direct line-of-sight from each microphone location to the source during the data collection.

#### 5.1.2 Near-field ground run-up terrain

The test site terrain shall be flat and homogeneous within a 75-foot radius circle centered on the MARP location. The closest vertical reflecting surface 10<sup>2</sup> feet or larger shall be at least 200 feet from the MARP location.

#### 5.1.3 Far-field ground run-up terrain

The test site terrain shall be flat and homogeneous within a 75-foot radius circle centered on the nozzle plane location. From the 75-foot radius circle to a 250-foot radius circle centered on the nozzle plane location, the deviation from flat shall not exceed  $\pm 1$  foot. From the 250-foot radius circle to the most distant microphone, the deviation from flat shall not exceed  $\pm 2$  feet.

#### 5.1.4 Flyover terrain

The test site terrain shall permit direct line-of-sight from each microphone location to the source during the data collection portion of the flyover measurements. No obstructions that significantly influence the sound field from the airplane shall 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  $80^\circ$  from this axis. Additionally, if crane or tower microphones are used, the terrain shall be flat (the deviation from flat shall not exceed  $\pm 20$  feet) and homogeneous within the area between the cranes or towers.

NOTE Personnel conducting the measurements could constitute an obstruction.

### 5.2 Ground impedance

The acoustic impedance of the measurement site shall be measured using the procedure of ANSI/ASA S1.18-2010. A set of at least four measurement locations within the test site shall be chosen. The locations shall be selected to characterize all ground surface types and conditions (minimum of two locations per ground surface type and condition), evenly distributed over the test area. A single location shall be chosen to be measured daily during the test. If the acoustic impedance at this location changes more than 20% from previous measurements, then new measurements shall be taken at all locations.

### 5.3 Weather requirements

#### 5.3.1 Temperature

The temperature measured at 33 feet AGL shall be no less than  $36^\circ\text{F}$  and shall be no more than  $95^\circ\text{F}$  (reference FAA FAR 36).

#### 5.3.2 Temperature gradient

##### 5.3.2.1 General requirements

The temperature gradient shall be measured using one or more methods as referenced in 5.3.2.2 or 5.3.2.3 as applicable and shall be reported.

##### 5.3.2.2 Flyover 5 feet to 1000 feet AGL temperature gradient

###### *Method A – NASA balloon-type procedure*

A helium-filled balloon tethered to an electric winch and located typically 1 mile from the microphone array shall be used to hoist a weather sensor package before, during, and after noise data collection. The sensor package shall provide as a minimum, wind speed and direction, relative humidity, temperature, and barometric pressure at a sample rate of at least once per second. During periods of acoustic data acquisition the balloon shall be continuously traversed from ground level to altitudes up to 1000 feet AGL at a rate of approximately one foot per second. The time correlated data shall be recorded and post processed to provide a weather profile for the time associated with each noise data collection point.

###### *Method B – Light Detection and Ranging (LIDAR) procedure*

A calibrated LIDAR system shall be used to collect temperature, wind speed, and wind direction data over at least the primary data collection volume of plus and minus 1000 feet from the center of the measurement array and up to at least 1000 feet AGL. The temperature, wind speed, and wind direction data shall be measured before, during, and after noise data collection. The time-correlated data shall be recorded and processed to provide a temperature and wind profile for the time associated with each noise data collection point.