
AMERICAN NATIONAL STANDARD

Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering/survey methods for use *in situ* in a reverberant environment

(a Nationally Adopted International Standard)

ANSI/ASA S12.57-2011 / ISO 3747:2010

Accredited Standards Committee S12, Noise

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Secretariat:

Acoustical Society of America

Approved on August 26, 2011 by:

American National Standards Institute, Inc.

Abstract

This American National Standard specifies a method for determining the sound power level or sound energy level of a noise source by comparing measured sound pressure levels emitted by a noise source (machinery or equipment) mounted *in situ* in a reverberant environment, with those from a calibrated reference sound source. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands of width one octave, is calculated using those measurements. The sound power level or sound energy level with frequency A-weighting applied is calculated using the octave-band levels.

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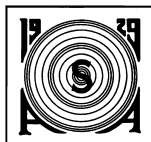
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Foreword

[This Foreword is for information only and is not a part of the American National Standard ANSI/ASA S12.57-2011 / ISO 3747:2010 American National Standard Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment.]

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 a revision of ANSI S12.57-2002 / ISO 3747:2000, which has been technically revised.

This Standard is identical to International Standard ISO 3747, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use in situ in a reverberant environment*, which was prepared by Technical Committee ISO/TC 43 Subcommittee SC 1, Noise. However, in conformance with ANSI and ISO rules, the words "American National Standard" replace the words "International Standard" where they appear in the ISO document, decimal points were substituted in place of the decimal commas used in ISO documents, and American English spelling is used in place of British English spelling.

The ANSI or ANSI/ASA equivalents for the ISO standards in the ISO 3740 series and other referenced nationally adopted standards are given below:

- ANSI S12.5 / ISO 6926 is an identical national adoption of ISO 6926;
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Introduction

This American National Standard is a national adoption of one of the series ISO 3741^[2] to ISO 3747, which specify various methods for determining the sound power levels and sound energy levels of noise sources including machinery, equipment and their sub-assemblies. The selection of one of the methods from the series for use in a particular application depends on the purpose of the test to determine the sound power level or sound energy level and on the facilities available. General guidelines to assist in the selection are provided in ISO 3740^[1]. ISO 3740^[1] to ISO 3747 give only general principles regarding the operating and mounting conditions of the machinery or equipment for the purposes of the test. It is important that test codes be established for individual kinds of noise source, in order to give detailed requirements for mounting, loading, and operating conditions under which the sound power levels or sound energy levels are to be obtained.

The method given in this American National Standard is based on a comparison of the sound pressure levels in octave frequency bands of a noise source under test with those of a calibrated reference sound source; A-weighted sound power levels or sound energy levels may be calculated from the octave-band levels. The method is applied where the noise source is found *in situ* and as such is suitable for larger pieces of stationary equipment which, due to their manner of operation or installation, cannot readily be moved.

The method specified in this American National Standard permits the determination of the sound power level and the sound energy level in octave bands from which the A-weighted value is calculated.

This American National Standard describes a method giving results of either ISO 12001:1996, accuracy grade 2 (engineering grade) or ISO 12001:1996, accuracy grade 3 (survey grade), depending on the extent to which the requirements concerning the test environment are met. For applications where greater accuracy is required, reference can be made to ISO 3741^[2], ISO 3744^[5] or an appropriate part of ISO 9614^{[17]-[19]}. If the relevant criteria for the measurement environment specified in this American National Standard are not met, it might be possible to refer to another standard from this series, or to an appropriate part of ISO 9614^{[17]-[19]}.

American National Standard

Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering/survey methods for use *in situ* in a reverberant environment

1 Scope

1.1 General

This American National Standard specifies a method for determining the sound power level or sound energy level of a noise source by comparing measured sound pressure levels emitted by a noise source (machinery or equipment) mounted *in situ* in a reverberant environment, with those from a calibrated reference sound source. The sound power level (or, in the case of noise bursts or transient noise emission, the sound energy level) produced by the noise source, in frequency bands of width one octave, is calculated using those measurements. The sound power level or sound energy level with frequency A-weighting applied is calculated using the octave-band levels.

1.2 Types of noise and noise sources

The method specified in this American National Standard is suitable for all types of noise (steady, non-steady, fluctuating, isolated bursts of sound energy, etc.) defined in ISO 12001. The method is primarily applicable to sources which emit broad-band noise. It can, however, also be used for sources which emit narrow-band noise or discrete tones, although there is a possibility that the measurement reproducibility is then degraded.

The noise source under test can be a device, machine, component or sub-assembly, especially one which is non-movable.

1.3 Test environment

The test environment that is applicable for measurements made in accordance with this American National Standard is a room where the sound pressure level at the microphone positions depends mainly on reflections from the room surfaces (see 4.1). In measurements of ISO 12001:1996, accuracy grade 2 (engineering grade), background noise in the test environment is low compared to that of the noise source or reference sound source (see 4.2).

1.4 Measurement uncertainty

Information is given on the uncertainty of the sound power levels and sound energy levels determined in accordance with this American National Standard, for measurements made in octave bands and for A-weighted frequency calculations performed on them. The uncertainty conforms with that of either ISO 12001:1996, accuracy grade 2 (engineering grade) or ISO 12001:1996, accuracy grade 3 (survey grade), depending on the extent to which the requirements concerning the test environment are met.

2 Normative references

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

ISO 5725 (all parts), *Accuracy (trueness and precision) of measurement methods and results*

ISO 6926, *Acoustics — Requirements for the performance and calibration of reference sound sources used for the determination of sound power levels*

ISO 12001:1996, *Acoustics — Noise emitted by machinery and equipment — Rules for the drafting and presentation of a noise test code*

ISO/IEC Guide 98-3, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

IEC 60942:2003, *Electroacoustics — Sound calibrators*

IEC 61260:1995, *Electroacoustics — Octave-band and fractional-octave-band filters*

IEC 61672-1:2002, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this document, the following definitions apply.

3.1

sound pressure

p

difference between instantaneous pressure and static pressure

NOTE 1 Adapted from ISO 80000-8:2007^[22], 8-9.2.

NOTE 2 Sound pressure is expressed in pascals.

3.2

sound pressure level

L_p

ten times the logarithm to the base 10 of the ratio of the square of the sound pressure, p , to the square of a reference value, p_0 , expressed in decibels:

$$L_p = 10 \lg \frac{p^2}{p_0^2} \text{ dB} \quad (1)$$

where the reference value, p_0 , is 20 μPa

[ISO/TR 25417:2007^[21], 2.2]

NOTE 1 If specific frequency and time weightings as specified in IEC 61672-1 and/or specific frequency bands are applied, this is indicated by appropriate subscripts; e.g. L_{pA} denotes the A-weighted sound pressure level.

NOTE 2 This definition is technically in accordance with ISO 80000-8:2007^[22], 8-22.

3.3 time-averaged sound pressure level

$L_{p,T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the sound pressure, p , during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0 , expressed in decibels

$$L_{p,T} = 10 \lg \left[\frac{\frac{1}{T} \int_{t_1}^{t_2} p^2(t) dt}{p_0^2} \right] \text{ dB} \quad (2)$$

where the reference value, p_0 , is 20 μPa

NOTE 1 In general, the subscript “ T ” is omitted since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

NOTE 2 Time-averaged sound pressure levels are often A-weighted, in which case they are denoted by $L_{pA,T}$, which is usually abbreviated to L_{pA} .

NOTE 3 Adapted from ISO/TR 25417:2007^[21], 2.3.

3.4 single event time-integrated sound pressure level

L_E
ten times the logarithm to the base 10 of the ratio of the integral of the square of the sound pressure, p , of an isolated single sound event (burst of sound or transient sound) over a stated time interval T (starting at t_1 and ending at t_2) to a reference value, E_0 , expressed in decibels

$$L_E = 10 \lg \left[\frac{\int_{t_1}^{t_2} p^2(t) dt}{E_0} \right] \text{ dB} \quad (3)$$

where the reference value, E_0 , is $(20 \mu\text{Pa})^2 \text{ s} = 4 \times 10^{-10} \text{ Pa}^2 \text{ s}$

NOTE 1 This quantity can be obtained by $L_{p,T} + 10 \lg(T/T_0)$ dB, where $T_0 = 1 \text{ s}$.

NOTE 2 When used to measure sound immission, this quantity is usually called “sound exposure level” (see ISO/TR 25417:2007^[21]).

3.5 measurement time interval

T
portion or a multiple of an operational period or operational cycle of the noise source under test for which the time-averaged sound pressure level is determined

NOTE Measurement time interval is expressed in seconds.

3.6

comparison method

method by which the sound power level or sound energy level of a noise source under test is determined from a comparison of the sound pressure levels produced by the source under test with those of a reference sound source of known sound power output, when both sources are operated in the same environment

3.7

reverberant sound field

that portion of the sound field in the test room over which the influence of sound received directly from the source is negligible

3.8

reference sound source

sound source meeting specified requirements

NOTE For the purposes of this American National Standard, the requirements are those specified in ISO 6926:1999, Clause 5.

3.9

calibration position

position, well-defined relative to reflecting surfaces, in which the reference sound source has been calibrated

3.10

excess of sound pressure level at a given distance

ΔL_f

difference, at a given distance, between the sound pressure level of a sound source in a given room and the sound pressure level that would be expected in a free sound field, expressed in decibels

NOTE This term and its definition differ from that given in ISO 14257:2001^[20], 3.6, which relates to an average difference over a given distance range.

3.11

frequency range of interest

for general purposes, the frequency range of octave bands with nominal mid-band frequencies from 125 Hz to 8 000 Hz

NOTE For special purposes, the frequency range can be extended or reduced, provided that the test environment, reference sound source, and instrument specifications are satisfactory for use over the modified frequency range. Any change to the frequency range of interest is clearly indicated in the test report. Measurements are not valid if the A-weighted levels are predominantly determined by high or low frequencies outside the frequency range of interest.

3.12

reference box

hypothetical right parallelepiped terminating on the floor of the test environment on which the noise source under test is located, that just encloses the source including all the significant sound-radiating components and any test table on which the source is mounted

3.13 measurement distance

d_m

distance from the nearest point of the reference box to a microphone position

NOTE Measurement distance is expressed in meters.

3.14 background noise

noise from all sources other than the noise source under test

NOTE Background noise includes contributions from airborne sound, noise from structure-borne vibration, and electrical noise in the instrumentation.

3.15 background noise correction

K_1

correction applied to the measured octave-band sound pressure levels at each microphone position to account for the influence of background noise

NOTE 1 Background noise correction is expressed in decibels.

NOTE 2 The background noise correction is frequency dependent; the correction in the case of a frequency band is denoted K_{1f} , where f denotes the relevant mid-band frequency.

3.16 sound power

P

through a surface, product of the sound pressure, p , and the component of the particle velocity, u_n , at a point on the surface in the direction normal to the surface, integrated over that surface

[ISO 80000-8:2007^[22], 8-16]

NOTE 1 Sound power is expressed in watts.

NOTE 2 The quantity relates to the rate per time at which airborne sound energy is radiated by a source.

3.17 sound power level

L_W

ten times the logarithm to the base 10 of the ratio of the sound power of a source, P , to a reference value, P_0 , expressed in decibels

$$L_W = 10 \lg \frac{P}{P_0} \text{ dB} \quad (4)$$

where the reference value, P_0 , is 1 pW

NOTE 1 If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. L_{WA} denotes the A-weighted sound power level.

NOTE 2 This definition is technically in accordance with ISO 80000-8:2007^[22], 8-23.

[ISO/TR 25417:2007^[21], 2.9]

3.18 sound energy

J

integral of the sound power, P , over a stated time interval of duration T (starting at t_1 and ending at t_2)

$$J = \int_{t_1}^{t_2} P(t) dt \quad (5)$$

NOTE 1 Sound energy is expressed in joules.

NOTE 2 The quantity is particularly relevant for non-stationary, intermittent sound events.

[ISO/TR 25417:2007^[21], 2.10]

3.19 sound energy level

L_J

ten times the logarithm to the base 10 of the ratio of the sound energy, J , to a reference value, J_0 , expressed in decibels

$$L_J = 10 \lg \frac{J}{J_0} \text{ dB} \quad (6)$$

where the reference value, J_0 , is 1 pJ

NOTE If a specific frequency weighting as specified in IEC 61672-1 and/or specific frequency bands are applied, this should be indicated by appropriate subscripts; e.g. L_{JA} denotes the A-weighted sound energy level.

[ISO/TR 25417:2007^[21], 2.11]

4 Test environment

4.1 Criterion for acoustic adequacy of test environment

The test environment is where the noise source under test is found *in situ*, i.e. either where the source is built or where it normally operates. The method of test specified in this American National Standard is for application in a reverberant sound field. The test environment shall therefore be sufficiently reverberant to cause the directivity of the source under test to have an insignificant influence on the sound pressure levels measured according to 7.5 and 7.6. The indicator, excess of sound pressure level at a given distance, ΔL_p , shall be determined in accordance with Annex A, and shall have a magnitude of at least 7 dB in regions where the requirement for a reverberant sound field is fulfilled. This indicator serves as the parameter by which to assess the measurement uncertainty, see Clause 9.

4.2 Criterion for background noise

At each microphone position, the octave-band sound pressure levels due to background noise shall be at least 6 dB and preferably more than 15 dB below the octave-band sound pressure levels from the noise source under test and from the reference sound source.