Teknisk specifikation
SIS-ISO/TS 7849-1:2009

Publicerad/Published: 2009-05-05
Utgåva/Edition: 1
Språk/Language: engelska/English
ICS: 17.140.20

Akustik – Bestämning av luftburna ljudeffektnivåer från maskiner medelst vibrationsmätning – Del 1: Överslagsmetod med fast strålningsfaktor (ISO/TS 7849-1:2009, IDT)

Acoustics – Determination of airborne sound power levels emitted by machinery using vibration measurement – Part 1: Survey method using a fixed radiation factor (ISO/TS 7849-1:2009, IDT)

SWEDISH STANDARDS INSTITUTE

Hitta rätt produkt och ett leveranssätt som passar dig

Standarder
Genom att följa gällande standard både effektiviserar och säkrar du ditt arbete. Många standarder ingår dessutom ofta i paket.

Tjänster
Abonnemang är tjänsten där vi uppdaterar dig med aktuella standarder när förändringar sker på dem du valt att abonnera på. På så sätt är du säker på att du alltid arbetar efter rätt utgåva.
e-nav är vår online-tjänst som ger dig och dina kollegor tillgång till standarder ni valt att abonnera på dygnet runt. Med e-nav kan samma standard användas av flera personer samtidigt.

Leveranssätt
Du väljer hur du vill ha dina standarder levererade. Vi kan erbjuda dig dem på papper och som pdf.

Andra produkter
Vi har böcker som underlättar arbetet att följa en standard. Med våra böcker får du ökad förståelse för hur standarder ska följas och vilka fördelar den ger dig i ditt arbete. Vi tar fram många egna publikationer och fungerar även som återförsäljare. Det gör att du hos oss kan hitta över 500 unika titlar. Vi har även tekniska rapporter, specifikationer och "workshop agreement".
Matriser är en översikt på standarder och handböcker som bör läsas tillsammans. De finns på sis.se och ger dig en bra bild över hur olika produkter hör ihop.

Standardiseringsprojekt
Du kan påverka innehållet i framtida standarder genom att delta i någon av SIS ca 400 Tekniska Kommittéer.

Find the right product and the type of delivery that suits you

Standards
By complying with current standards, you can make your work more efficient and ensure reliability. Also, several of the standards are often supplied in packages.

Services
Subscription is the service that keeps you up to date with current standards when changes occur in the ones you have chosen to subscribe to. This ensures that you are always working with the right edition.
e-nav is our online service that gives you and your colleagues access to the standards you subscribe to 24 hours a day. With e-nav, the same standards can be used by several people at once.

Type of delivery
You choose how you want your standards delivered. We can supply them both on paper and as PDF files.

Other products
We have books that facilitate standards compliance. They make it easier to understand how compliance works and how this benefits you in your operation. We produce many publications of our own, and also act as retailers. This means that we have more than 500 unique titles for you to choose from. We also have technical reports, specifications and workshop agreements.
Matrices, listed at sis.se, provide an overview of which publications belong together.

Standardisation project
You can influence the content of future standards by taking part in one or other of SIS's 400 or so Technical Committees.

Denna tekniska specifikation är inte en svensk standard. Detta dokument innehåller den engelska språkversionen av ISO/TS 7849-1:2009.

This Technical Specifikation is not a Swedish Standard. This document contains the English version of ISO/TS 7849-1:2009.

Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00.
Standarder kan beställas hos SIS Förlag AB som även lämnar allmänna upplysningar om svensk och utländsk standard.

Information about the content of the standard is available from the Swedish Standards Institute (SIS), tel +46 8 555 520 00.
Standards may be ordered from SIS Förlag AB, who can also provide general information about Swedish and foreign standards.

SIS Förlag AB, SE 118 80 Stockholm, Sweden. Tel: +46 8 555 523 10. Fax: +46 8 555 523 11.
E-mail: sis.sales@sis.se Internet: www.sis.se

Contents

Page

Foreword iv
Introduction v
1 Scope 1
2 Normative references 1
3 Terms and definitions 2
4 Principle 4
5 Measuring instrumentation 5
5.1 General 5
5.2 Vibration transducer 5
5.3 Non-contacting transducers 5
5.4 Amplifier 6
5.5 Integrator 6
5.6 Calibration 6
6 Installation and operation of source under test 6
6.1 General 6
6.2 Description of the machine 7
6.3 Installation 7
6.4 Operating conditions 7
7 Determination of the vibratory velocity on the vibrating measurement surface 7
7.1 General 7
7.2 Vibrating measurement surface 7
7.3 Number of measurement positions 8
7.4 Environmental conditions 8
7.5 Measurement procedure 9
7.6 Mounting of the vibration transducer 9
8 Calculations 9
8.1 Correction for extraneous vibratory velocity 9
8.2 Determination of the mean A-weighted vibratory velocity level on the vibrating measurement surface 10
8.3 Calculation of the upper limit of the A-weighted airborne sound power level caused by radiation of structure vibration generated sound 11
9 Measurement uncertainty 11
10 Information to be recorded 13
10.1 Machine under test 13
10.2 Measurement conditions 13
10.3 Measuring instrumentation 13
10.4 Acoustical data 13
Annex A (informative) Use of the vibration transducer 14
Annex B (informative) Guidance on the development of information on measurement uncertainty 16
Bibliography 19

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

— an ISO Technical Specification (ISO/TS) represents an agreement between the members of a technical committee and is accepted for publication if it is approved by 2/3 of the members of the committee casting a vote.

An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 7849-1 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

This first edition of ISO/TS 7849-1, together with ISO/TS 7849-2, cancel and replace the first edition of ISO/TR 7849:1987, which has been technically revised.

ISO/TS 7849 consists of the following parts, under the general title *Acoustics — Determination of airborne sound power levels emitted by machinery using vibration measurement*:

— *Part 1: Survey method using a fixed radiation factor*

— *Part 2: Engineering method including determination of the adequate radiation factor*

The following part is under preparation:

— Part 3: Amplitude and phase measurements

Introduction

This part of ISO/TS 7849 gives a procedure for the determination of the sound power of the airborne noise caused by machinery vibration.

The determination of airborne noise emission of a machine by measuring vibration of the machine's outer surface may be of interest when:

— undesired background noise (e.g. noise from other machines or sound reflected by room boundaries) is high compared with the noise radiated directly by the machine under test;

— noise radiated by structure vibration is to be separated from noise of aerodynamic origin;

— noise radiated by structure vibration is high compared to the aerodynamic component so that the total noise radiation is predominantly affected by the structure vibration;

— sound intensity measurement techniques [ISO 9614 (all parts)[12]] cannot easily be applied;

— structure vibration generated noise from only a part of a machine, or from a component of a machine set, is to be determined in the presence of noise from the other parts of the whole machine.

ISO/TS 7849 (all parts) describes methods for the determination of the airborne noise emission of a machine caused by vibration of its outer surface, expressed by the associated A-weighted airborne sound power being related to normalized meteorological conditions. This airborne sound power is determined under the assumption that this quantity is proportional to the mean square value of the normal component of the velocity averaged over the area of the vibrating outer surface of the machine, and is directly proportional to the area of the vibrating surface.

The calculation of the airborne sound power needs data of the radiation factor in principle. For this part of ISO/TS 7849 a radiation factor of 1 is assumed allowing the determination of an upper limit for the radiated A-weighted sound power level. For typical machines this upper limit may exceed the true A-weighted sound power level determined by the intensity procedure of ISO 9614 (all parts)[12] by up to 10 dB. The A-weighted sound power level determined according to this part of ISO/TS 7849 can be used for sound power level comparison of relevant vibrating machinery noise of the same family with similar design.

Acoustics — Determination of airborne sound power levels emitted by machinery using vibration measurement —

Part 1: Survey method using a fixed radiation factor

1 Scope

This part of ISO/TS 7849 gives basic requirements for reproducible methods for the determination of an upper limit for the A-weighted sound power level of the noise emitted by machinery or equipment by using surface vibration measurements. The method is only applicable to noise which is emitted by vibrating surfaces of solid structures and not to noise generated aerodynamically.

This vibration measurement method is especially applicable in cases where accurate direct airborne noise measurements, e.g. as specified in ISO 3746[7], ISO 3747[8], and ISO 9614 (all parts)[12], are not possible because of high background noise or other parasitic environmental interferences; or if a distinction is required between the total radiated sound power and its structure vibration generated component.

NOTE 1 One of the applications of this part of ISO/TS 7849 is the distinction between the radiation of airborne sound power generated by structure vibration and the aerodynamic sound power components. Such a distinction is not feasible with ISO 3746[7] and ISO 9614 (all parts)[12].

NOTE 2 Problems can occur if the noise is generated by small parts of machinery surfaces (sliding contacts, e.g. slip ring brush or the commutator and the brush in electrical machines).

The methods described in this part of ISO/TS 7849 apply mainly to processes that are stationary with respect to time.

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 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

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

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

3 Terms and definitions

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

3.1
structure vibration generated sound
airborne sound caused by structure vibration in the audible frequency range

NOTE For the purposes of this part of ISO/TS 7849, structure vibration generated sound is determined either from the vibratory velocity or the vibratory acceleration of the surface of the solid structure.

3.2
machine
⟨airborne sound power level measurement⟩ equipment which incorporates a single or several noise sources

3.3
vibratory velocity
v
root-mean square (r.m.s.) value of the component of the velocity of a vibrating surface in the direction normal to the surface

NOTE 1 The vibratory velocity, v, is the time integral of the vibratory acceleration, whose r.m.s. value is given for sinusoidal vibration by:

$$v = \frac{a}{2\pi f} \tag{1}$$

where

a is the r.m.s. acceleration;

f is the frequency.

The vibratory velocity, v, is the time derivative of the vibratory displacement, s, ds/dt. For sinusoidal vibration, the r.m.s. velocity, v, is given by:

$$v = 2\pi f s \tag{2}$$

where s is the r.m.s. displacement.

NOTE 2 In this part of ISO/TS 7849, the vibratory velocity is usually applied with A-weighting, denoted v_{A}.

3.4
A-weighted vibratory velocity level
$L_{v\mathrm{A}}$
ten times the logarithm to the base 10 of the ratio of the square of the r.m.s. value of the A-weighted vibratory velocity, v_{A}, to the square of a reference value, v_0, expressed in decibels:

$$L_{v\mathrm{A}} = 10 \lg \frac{v_{\mathrm{A}}^2}{v_0^2} \text{ dB} \tag{3}$$

where

v_A is the A-weighted r.m.s. value of the vibratory velocity, in metres per second1);

v_0 is the reference value for the velocity and is equal to 5×10^{-8} m/s2).

NOTE For airborne and structure vibration generated sound, the reference value, $v_0 = 50$ nm/s has the property that it leads, together with $p_0 = 2 \times 10^{-5}$ Pa, to the reference value of the intensity level $I_0 = 1 \times 10^{-12}$ W/m^2 and to the characteristic impedance of air by $p_0/v_0 = 400$ N s/m^3.

3.5
A-weighted radiation factor
ε_A
factor expressing the efficiency of sound radiation given by:

$$\varepsilon_A = \frac{P_A}{Z_c \, S \, \overline{v_A^2}} \tag{4}$$

where

P_A is the A-weighted airborne sound power emitted by the vibrating surface of the machine, determined according to ISO 9614 (all parts)[12];

S is the area of the defined outer surface of the machine under test (vibrating measurement surface; see 3.8);

$\overline{v_A^2}$ is the squared A-weighted r.m.s. value of the vibratory velocity averaged over S;

Z_c is the characteristic impedance of air.

NOTE The four quantities ε_A, P_A, $\overline{v_A^2}$, and Z_c relate to the same period of time and to the same meteorological conditions (atmospheric temperature, θ, and barometric pressure, B).

3.6
A-weighted airborne sound power level
L_{WA}
ten times the logarithm to the base 10 of the ratio of the A-weighted airborne sound power emitted by the surface of a machine, P_A, to a reference value, P_0, expressed in decibels

$$L_{WA} = 10 \lg \frac{P_A}{P_0} \text{ dB} \tag{5}$$

where the reference value, P_0, is 10^{-12} W

3.7
upper limit of A-weighted airborne sound power level
$L_{WA,max}$
A-weighted airborne sound power level determined in accordance with the method described in this part of ISO/TS 7849

---

1) A subscript “eff” is dropped, since only r.m.s. values are used throughout this part of ISO/TS 7849.

2) In ISO 1683[1], two reference values for the velocity level are mentioned: $v_0 = 10^{-9}$ m/s and 5×10^{-8} m/s. The latter is intended for cases of airborne and structure vibration generated sound and is therefore used in this part of ISO/TS 7849. A choice of $v_0 = 10^{-9}$ m/s results in a vibratory velocity level which is 34 dB higher than the level used in this part of ISO/TS 7849. Therefore, if $v_0 = 10^{-9}$ m/s is used, subtract 34 dB from the right-hand sides of Equations (7), (8), and (11).

3.8
vibrating measurement surface
surface of a machine radiating the structure vibration generated sound where the measurement positions are located

NOTE Its area is designated by the symbol S.

3.9
extraneous vibratory velocity level
vibratory velocity level, caused by all sources other than the source under test

NOTE Extraneous vibratory velocity levels originate, for example, from coupled assemblies.

4 Principle

4.1 The A-weighted airborne sound power radiated by a machine or equipment caused by structure vibrations of its outer surface only, P_{A}, is generally determined by Equation (6) [see also Equation (4)]

$$P_{\text{A}} = Z_{\text{c}} \overline{v_{\text{A}}^2} S \, \varepsilon_{\text{A}} \tag{6}$$

For the purpose of this part of ISO/TS 7849, the A-weighted radiation factor $\varepsilon_{\text{A}} = 1$ 3), and for Z_{c} the normalized characteristic impedance $Z_{\text{c,n}} = 411$ N s/m^3 is used.

NOTE The normalized characteristic impedance $Z_{\text{c,n}} = 411$ N s/m^3 is used in accordance with the basic International Standards for which ISO 3740[2] gives usage guidelines, and corresponds to meteorological conditions for atmospheric temperature, $\theta_0 = 23{,}0$ °C, and barometric pressure, $B_0 = 1{,}013 \times 10^5$ Pa.

These assumptions yield the upper limit of the A-weighted airborne sound power

$$P_{\text{A,max}} = Z_{\text{c,n}} \overline{v_{\text{A}}^2} \, S \tag{7}$$

which forms the basis for the method described in this part of ISO/TS 7849, requiring only $\overline{v_{\text{A}}^2}$ and S to be determined.

4.2 The value of $\overline{v_{\text{A}}^2}$ is obtained from measurements of the A-weighted r.m.s. vibratory velocity component perpendicular to the outer surface of the machine and taken for a sufficient number of measurement positions distributed over its relevant outer surface. The array and number of measurement positions can be regarded as sufficient if the value of $\overline{v_{\text{A}}^2}$ remains stable within the precision of the method for an increasing number and changed array of measurement positions.

It may be desirable to subdivide the surface area of the machine in order to rank the sound power radiated from different components. The implication of this subdivision is that each area radiates sound independently.

The spatial variation of vibration velocity depends on

a) the number of resonant modes excited simultaneously in the frequency band of interest;

b) the degree of non-uniformity of the structure (e.g. stiffness and inertia variation);

c) the spatial distribution of the exciting forces.

---

3) Under certain specific conditions, values $\varepsilon_{\text{A}} > 1$ are possible, but they seldom occur in the practice of machinery noise radiation. However, it may be assumed that, within the measurement uncertainty to be expected, the upper limit of the A-weighted sound power level determined in accordance with this part of ISO/TS 7849 also covers deviations caused by radiation factors larger than 1.

A major problem occurs when only a very few modes are excited within a frequency band of interest.

4.3 The area of the relevant outer surface of the machine, S, can be calculated easily if the shape of the outer surface of the machine is simple (e.g. cylindrical, spherical or composition of flat plates).

One problem is the radiation from connected structures, such as pipes, mounts, and supports, and the radiation from the framework, rib surfaces, perforated surfaces, and supporting structures.

It is recommended that S be defined for specific kinds of machinery.

5 Measuring instrumentation

5.1 General

Measuring instrumentation using vibration transducers and other non-contacting equipment is described here. For contacting accelerometers, it is convenient to make use of low mass-loading accelerometers, keeping in mind the frequency range of interest. However, for special purposes, other kinds of equipment and measurement techniques may be needed, e.g. non-contact devices and laser-Doppler methods (see Annex A).

5.2 Vibration transducer

The vibration transducer usually loads the vibrating surface.

For vibration measurements covering a wide frequency range, piezoelectric accelerometers are preferred. When selecting an accelerometer for a particular application, allowance should be made for the parameters of the transducer and the environmental conditions in which it is to be used.

Measurements are normally limited to the flat portion of the frequency response of the accelerometer, which is limited by the resonance of the transducer at the high frequency end. As a rule of thumb, the upper frequency limit for the measurements can be set to one-third of the resonance frequency of the accelerometer so that vibration components measured at this limit are not affected by more than 1 dB compared with those at lower frequencies.

Small, low-mass accelerometers may have high resonance frequencies but, in general, they have low sensitivity (dynamic range). Therefore, a compromise has to be made because high sensitivity normally entails a large piezoelectric assembly and, consequently, a relatively large, heavy unit with low resonance frequency.

The mass of the accelerometer becomes important when measuring low-mass test objects for the highest frequency of interest (see Annex A).

5.3 Non-contacting transducers

There are several transducers available for a non-contacting vibration measurement: capacitive transducers, eddy current transducers, and magnetic transducers. Holographic methods, laser triangulation sensors and laser Doppler vibrometers may also be used.

The transfer coefficient of capacitive transducers is inversely proportional to the distance between the transducer and the vibrating surface. Therefore, when using a capacitive transducer, a very fine geometric model of the surface of the structure vibration generating sound source is required, as well as an exact positioning system in order to keep the required (small) measurement distance. The same applies for magnetic transducers; furthermore, the transfer coefficient depends on the permeability of the outer surface.

When using laser holographic methods, the vibration data can be determined for a mesh of the whole surface in one shot, but for each point of the mesh only one magnitude and phase value can be received. Although necessary for sound radiation calculations, no spectral resolution of an operational deflection shape is possible with holography.