INTERNATIONAL STANDARD

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Acoustics — Noise test code for compressors and vacuum pumps — Engineering method (Grade 2)

Acoustique — Code d'essai acoustique pour les compresseurs et les pompes à vide — Méthode d'expertise (classe de précision 2)

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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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.

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 2151 was prepared by Technical Committee ISO/TC 118, *Compressors, pneumatic tools and pneumatic machines*, Subcommittee SC 6, *Air compressors*.

This second edition cancels and replaces the first edition (ISO 2151:1972), which has been technically revised.

Introduction

The noise test code presented by this International Standard describes methods for determining and presenting the acoustical characteristics of compressors and vacuum pumps, i.e. the total noise level from the compressor or vacuum pump expressed as sound power level, or the emission sound pressure level at the work station or other specified positions.

Based on current industry practice, this noise test code requires the compressor or vacuum pump under test to be run under conditions representing the noisiest operation in typical usage — full-load for compressors and off-load for vacuum pumps.

It needs to be noted that operators' exposure to noise depends upon the characteristics of individual applications and environmental factors beyond the control of the manufacturers of compressors and vacuum pumps.

This International Standard does not give requirements for octave band analysis, however, where there is an interest this can be undertaken.

Acoustics — Noise test code for compressors and vacuum pumps — Engineering method (Grade 2)

1 Scope

This International Standard specifies methods for the measurement, determination and declaration of the noise emission from portable and stationary compressors and vacuum pumps. It prescribes the mounting, loading and working conditions under which measurements are to be made, and includes measurement or determination of the noise emission expressed as

— the sound power level under specified load conditions,

— the emission sound pressure level at the work station under specified load conditions.

It is applicable to

— compressors for various types of gases,

— oil-lubricated air compressors,

— oil-flooded air compressors,

— water injected air compressors,

— oil-free air compressors,

— compressors for handling hazardous gases (gas compressors),

— compressors for handling oxygen,

— compressors for handling acetylene,

— high-pressure compressors [over 4 Mpa (40 bar)],

— compressors for application at low inlet temperatures, i.e. below 0 °C,

— large compressors (over 1 000 kW input power),

— portable and skid-mounted air compressors, and

— rotary positive displacement blowers and centrifugal blowers and exhausters in applications $\leqslant$ 0,2 MPa ($\leqslant$ 2 bar).

It is not applicable to

— compressors for gases other than acetylene having a maximum allowable working pressure of less than 0,5 bar/0,05 MPa,

— refrigerant compressors used in refrigerating systems or heat pumps,

— hand-held portable compressors.

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 3744:1994, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*

ISO 4871:1996, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

ISO 9614-1:1993, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 1: Measurement at discrete points*

ISO 9614-2:1996, *Acoustics — Determination of sound power levels of noise sources using sound intensity — Part 2: Measurement by scanning*

ISO 11201:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane*

ISO 11202:1995, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Survey method in situ*

ISO 11203:1995, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions from the sound power level*

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

3 Terms and definitions

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

3.1
compressor
machine which compresses air, gases or vapours to a pressure higher than the inlet pressure

NOTE A compressor comprises the bare compressor itself, the prime mover and any component or device supplied with the compressor.

3.2
vacuum pump
device for creating, improving and/or maintaining vacuum

NOTE A vacuum pump comprises the bare pump, the prime mover and any component or device supplied with the vacuum pump.

3.3
emission
airborne sound radiated by a well-defined noise source (e.g. the machine under test) under specified operating and mounting conditions

NOTE 1 Adapted from ISO 11203:1995.

NOTE 2 Noise emission values can be incorporated in a product label and/or published in a product specification. The basic noise emission descriptors are the sound power level of the product itself and the emission sound pressure levels at the work station and at other specified positions in the vicinity of the product (if any).

3.4
emission sound pressure
p
sound pressure, expressed in pascals, at a specified position near a noise source, when the source is in operation under specified operating and mounting conditions on a reflecting plane surface, corrected for background noise and reflections from room surfaces other than the plane over which the machine under test is placed

NOTE Adapted from ISO 11203:1995.

3.5
emission sound pressure level
L_p
ten times the logarithm to the base 10 of the ratio of the square of the emission sound pressure to the square of the reference sound pressure, expressed in decibels, and measured with a particular time weighting and a particular frequency weighting selected from those defined in IEC 61672-1:2002

EXAMPLE A-weighted emission sound pressure level, $L_{p\mathrm{A}}$.

NOTE 1 The reference sound pressure is 20 µPa.

NOTE 2 $L_{p\mathrm{A}}$ levels are established as $L_{p\mathrm{A}eqT}$ time-averaged sound pressure levels measured with an integrating-averaging sound level meter meeting the requirements of IEC 61672-1:2002. $L_{p\mathrm{A}eqT}$ is usually abbreviated to $L_{p\mathrm{A}}$. For further details of $L_{p\mathrm{A}eqT}$ see ISO 3744:1994, 3.2.1.

NOTE 3 Adapted from ISO 11203:1995.

3.6
sound power
W
rate per unit time, expressed in watts, at which airborne sound energy is radiated by a source

[ISO 3744:1994]

3.7
sound power level
L_W
ten times the logarithm to the base 10 of the ratio of the sound power radiated by the source under test to the reference sound power, expressed in decibels

NOTE 1 The frequency weighting or the width of the frequency band must be indicated. For example, A-weighted sound power level $L_{W\mathrm{A}}$.

NOTE 2 The reference sound power is 1 pW (1 pW = 10^{-12} W).

NOTE 3 Adapted from ISO 3744:1994.

3.8
sound intensity
product of the sound pressure at a point and the associated particle velocity

NOTE 1 It is a vectorial quantity.

NOTE 2 See ISO 9614-1 and ISO 9614-2 for further guidance on sound intensity.

3.9
partial sound power
P_i
time-averaged rate of flow of sound energy through an element (segment) of a measurement surface, given by

$$P_i = \vec{I}_i \times \vec{S}_i = I_{ni} \times S_i$$

where

I_{ni} is the signed magnitude of the normal sound intensity component measured at position i on the measurement surface;

S_i is the area of the segment of surface associated with point i.

3.10
background noise correction
K_1
correction term to account for the influence of background noise on the surface sound pressure level, expressed in decibels

NOTE 1 K_1 is frequency dependent.

NOTE 2 The correction in the case of A-weighting is denoted K_{1A}.

NOTE 3 Adapted from ISO 3744:1994.

3.11
environmental correction
K_2

correction term to account for the influence of reflected or absorbed sound on the surface sound pressure level, expressed in decibels

NOTE 1 K_2 is frequency dependent.

NOTE 2 The correction in the case of A-weighting is denoted K_{2A}.

NOTE 3 Adapted from ISO 3744:1994.

3.12
reference box
hypothetical surface which is the smallest rectangular parallelepiped that just encloses the source and terminates on the reflecting plane

[ISO 3744:1994]

3.13
measurement surface
hypothetical surface of area S, enveloping the source, on which the measurements are made

NOTE The measurement surface terminates on the reflecting plane.

3.14
measurement distance
distance, d, from the reference box to the parallelepiped measurement surface, or radius, r, of the hemispherical measurement surface

NOTE Adapted from ISO 3744:1994.

3.15
noise emission declaration
information on the noise emitted by the machine given by the manufacturer or supplier in technical documents or other literature concerning noise emission values

3.16
uncertainty
K
value of the total uncertainty associated with a measured noise emission value and the production, expressed in decibels

[ISO 4871:1996]

NOTE See also 4.2.

3.17
declared dual-number noise emission value
L, K
noise emission value, L, and its associated uncertainty, K, given in the noise emission declaration

NOTE 1 The symbols used are

— A-weighted sound power level, L_{WAd}, with uncertainty, K_{WAd}, and

— A-weighted emission sound pressure level, L_{pAd}, with uncertainty, K_{pAd}.

NOTE 2 Adapted from ISO 4871:1996.

3.18
work station
position in the vicinity of the compressor or vacuum pump under test, intended for the operator

NOTE 1 For the purposes of this International Standard, this is the surface enveloping the machine on test at a distance of 1 m from the reference box (see 3.12).

NOTE 2 Adapted from ISO 11203:1995.

3.19
A-weighted emission sound pressure level at the work station
L_{pWSA}
energy average of the A-weighted emission sound pressure levels at the work station

4 Sound power level determination

4.1 General

The sound power level shall be determined according to either of the basic standards ISO 3744 or ISO 9614-1 or ISO 9614-2, yielding Grade 2 level of accuracy.

The sound power level shall be given as A-weighted sound power level in decibels referenced to 1 pW (dB re 1 pW).

NOTE 1 Octave band information may also be obtained.

Consider the following when choosing which International Standard to use.

ISO 3744 assumes a non-reverberant environment and low background noise. It specifies a method to calculate sound power level from sound pressure levels measured on a surface enveloping the compressor or vacuum pump.

ISO 9614-1 or ISO 9614-2 can be used in most environments including semi-reverberant and/or when extraneous noise sources exist. It specifies methods for determining the sound power level from sound intensity levels measured on a surface enveloping the compressor or vacuum pump. Depending on the level of reverberation and extraneous noise, it can provide A-weighted sound power level data with Grade 2 or 3 accuracy.

NOTE 2 Further information on sound power is given in ISO 3740.

4.2 Uncertainty

The uncertainty of the determination of the sound power level comprises the measurement uncertainty of reproducibility (which includes repeatability) conditions and the uncertainty of production. For definitions of these components of the uncertainty, see ISO 4871.

In the basic standards ISO 3744, ISO 9614-1 and ISO 9614-2, measurement uncertainty is expressed in terms of the standard deviation of reproducibility. These standards provide a maximum value of the standard deviation of reproducibility. A manufacturer can use this value if he has no evidence, from his own experience with noise emission determination, that a different value applies to a particular machine or machine family.

Determination of production uncertainty is the responsibility of the product manufacturer. A method of determination is specified in ISO 4871:1996. Production uncertainty is expressed in terms of a standard deviation of production.

ISO 4871 indicates how the standard deviation of reproducibility and the standard deviation of production combine to provide uncertainty K.

Experience with the manufacture of compressors and vacuum pumps shows that uncertainty K for these machines and for A-weighted levels is typically + 3 dB for measurements according to engineering Grade 2. If a manufacturer can prove that his uncertainty statistically differs from 3 dB, he may use his own value of K.

4.3 Test arrangement

4.3.1 General

Vacuum pumps are used in a wide range of applications covering the complete vacuum spectrum. Designs of vacuum pumps are available for pumping any combination of gases and vapours. For many applications, two or more pumps are combined together and are supplied as a unit. These pumping units shall be tested as a single unit.

4.3.2 Measurement according to ISO 3744:1994

When ISO 3744:1994 is applied, the measurement surface shall be either a parallelepiped or a hemisphere. The reference box and the measurement surfaces are shown in Annex C and Annex D. The reference box should only include parts of the machine that are acoustically relevant; connecting pipes shall be excluded.

Annex C and Annex D show microphone positions for both surfaces and identify typical arrays of 9 microphones for a parallelepiped and 10 for a hemisphere. The actual number of microphone positions and their location depends on the size of the machine under test and the nature of its sound field. Guidance on this is given in ISO 3744:1994, 7.2 and 7.4 for the hemisphere and 7.3 and 7.4 for the parallelepiped.

For examples of typical reference boxes, see Annex E.

When using a parallelepiped array the preferred distance between the reference box and the measurement surface is 1 m. For further guidance see ISO 3744:1994, 7.3.