BRITISH STANDARD

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13487:2003

Heat exchangers — Forced convection air cooled refrigerant condensers and dry coolers — Sound measurement

The European Standard EN 13487:2003 has the status of a British Standard

ICS 17.140.20; 27.060.30

BSI
British Standards

National foreword

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The UK participation in its preparation was entrusted to Technical Committee RHE/30, Heat exchangers, which has the responsibility to:

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— present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

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Summary of pages

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Heat exchangers - Forced convection air cooled refrigerant condensers and dry coolers - Sound measurement

Echangeurs thermiques - Aérocondenseurs à convection forcée et batterie froide - Mesurage du bruit

Wärmeaustauscher - Ventilatorbelüftete Kältemittelverflüssiger und Trockenkühltürme - Schallmessung

This European Standard was approved by CEN on 1 October 2003.

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Foreword

This document EN 13487:2003 has been prepared by Technical Committee CEN/TC 110, “Heat exchangers”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2004, and conflicting national standards shall be withdrawn at the latest by June 2004.

Annexes A, B, C and D are normative. Annex E is informative.

This document contains a bibliography.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard : Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This European Standard is one of a series of European Standards dedicated to heat exchangers.

This standard provides information for assessing and presenting the acoustic characteristics of heat exchangers in operation.

This standard also provides information necessary for specifying and selecting the product which best suits the needs of the purchaser.

1 Scope

This standard specifies methods for uniform assessment and the recording of:

¾ the A-weighted sound power level;

¾ the sound power spectrum;

¾ a calculation method for an overall average sound pressure level at a given distance.

Among these data, the sound power level is the only unambiguous characteristic.

This standard is applicable to:

¾ forced convection air cooled refrigerant condensers as specified in EN 327;

¾ air cooled liquid coolers "dry coolers" as specified in EN 1048.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 327, *Heat exchangers - Forced convection air cooled refrigerant condensors - Test procedure for establishing performance.*

EN 1048, *Heat exchangers — Air-cooled liquid coolers "dry coolers" — Test procedure for establishing the performance*.

EN ISO 3741, *Acoustics - Determination of sound power levels of noise sources using sound pressure - Precision methods for reverberation rooms (ISO 3741:1999).*

EN ISO 3744, *Acoustics - Determination of sound power levels of noise sources using sound pressure - Engineering method in an essentially free field over a reflecting plane (ISO 3744:1994).*

EN ISO 9614-1, *Acoustics - Determination of sound power levels of noise sources using sound intensity - Part 1: Measurements at discrete points (ISO 9614-1:1993).*

EN ISO 12001, *Acoustics - Noise emitted by machinery and equipment - Rules for the drafting and presentation of a noise test code (ISO 12001:1996).*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:1999).*

EN 61672-1*, Electroacoustics - Sound level meters - Part 1: Specifications (IEC 61672-1:2002).*

EN 61672-2*, Electroacoustics - Sound level meters - Part 2: Pattern evaluation tests (IEC 61672-2:2003).*

3 Terms and definitions

For the purposes of this European Standard, the terms and definitions given in EN ISO 3744, with definitions from other appropriate ISO standards, where these do not contradict EN ISO 3744, together with the following apply.

3.1
forced convection air cooled refrigerant condenser
refrigeration system component that condenses refrigerant vapour by rejecting heat to air, which is mechanically circulated over its dry heat transfer surface by integral fans and fan drives. The heat transfer coil includes distributing and collecting headers. [See EN 327]

In the following " forced convection air cooled refrigerant condenser " is referred to as "apparatus".

3.2
forced convection air cooled liquid cooler; dry cooler
self contained system that cools a single phase liquid by rejecting sensible heat via a heat exchanger, to air that is mechanically circulated by integral fans.[See EN 1048]

In the following " forced convection air cooled liquid cooler; dry cooler " is referred to as "apparatus".

3.3
sound pressure level, L_P
ten times the logarithm to the base 10 of the ratio of the square of the sound pressure to the square of the reference sound pressure. Sound pressure levels are expressed in decibels

3.4
nominal sound pressure level
average A-weighted sound pressure level on an enveloping area in the shape of a parallelepiped with a given distance from the reference box, determined from the sound power level

NOTE For this purpose it is assumed that the sound radiation on the entire enveloping area is uniform.

3.5
sound spectrum
sound power level or sound pressure level (unweighted) in the octave bands with the center frequencies from 63 Hz to 8 000 Hz

3.6
reference box
hypothetical surface which is the smallest rectangular parallelepiped that just encloses the source and terminates on the reflecting plane

The reference box encloses the whole casing, including, if applicable, its normal supporting legs, fans and drives. Refrigerant / liquid connections and electrical supply cables are not taken into account when determining the reference box.

3.7
measurement surface
hypothetical surface of area S, enveloping the source, on which the measurement points are located. The measurement surface terminates on one reflecting plane

3.8
background noise
noise from all sources other than the source under test

3.9
module
geometrically similar group of components from which, when multiplied by an integer number, a range of units is built

A module typically comprises:

- a fan with motor;
- a heat exchanger coil;
- a casing which ensures the conduction of the air flow as intended, including supporting legs for vertical air flow.

For the purposes of this standard, the significant dimensions of a module are:

- size of the fan and its arrangement relative to the heat exchanger;
- speed of the fan;
- fin and tube geometry;
- air inlet area of the heat exchanger coil;
- depth of the coil in direction of the air flow (number of rows deep).

3.10
test subject
apparatus with all parts necessary to function and in standard form without accessories. This applies especially to the supporting legs (where applicable) and the heat exchanger coil

Where an apparatus is used for vertical and horizontal air flow direction, the measurement with vertical air flow direction is used as the basis for the evaluation of the sound data

4 Instrumentation

A precision sound pressure level meter with octave band filters, and a microphone as required by the respective standard and conforming to EN 61672-1 and EN 61672-2 shall be used and calibrated before the measurement of each apparatus.

5 Manufacturer's data

The test house shall be supplied with the following information on delivery of the apparatus:

- type and identification;
- dimensions which are necessary for the identification of the apparatus under test;
- type of fan, its manufacturer, and its identification;
- nominal voltage of the motors;
- nominal frequency of the supply
- nominal fan speeds;

¾ installation arrangement.

6 Test conditions

6.1 Test methods

The methods of test shall be as specified in EN ISO 3741, EN ISO 3744 or EN ISO 9614-1.

All methods used shall meet the minimum grade 2, Engineering, in accordance with EN ISO 12001.

NOTE It is recommended, for any apparatus, modules with only one fan are tested.

6.2 Operating condition of the test subject

The test subject shall be mounted and function in the manner prescribed for operation in the field. The test subject shall not be connected to refrigerant or liquid circuits.

Motors/fans shall be operated at the voltages, frequencies and fan speed settings, specified for use under steady state conditions.

6.3 Ambient conditions

The ambient conditions shall be such that the air velocity at the microphone is below 2m/s.

6.4 Arrangement of measuring points

6.4.1 General

The measuring points, i.e. the microphone positions shall be located on a measuring plane in accordance with annexes A and B. The distance between the reference box and the measuring planes shall be 1 m.

NOTE Due to the design of the test subjects, the microphone positions as specified in EN ISO 3744 are not suitable.

6.4.2 Apparatus with vertical air throw and draw through arrangement

The arrangement of measuring points shall be chosen in accordance with annex A.

The measuring points for apparatus with one fan shall be positioned on the partial measuring areas as follows (see A.1):

measuring point	partial measuring area
1, 2, 3, 4	a
5, 6	b
7, 8	c
9, 10	d
11, 12	e

For an apparatus with more than one fan additional measuring points shall be positioned on the partial measuring areas on the centreline between the fans and on straight lines connecting the measuring points specified above (see A.2).

6.4.3 Apparatus with horizontal air throw and draw through arrangement

The position of the measuring points shall be chosen according to annex B.

For modules with one fan, the measuring points are related to the partial measuring areas as follows (see B.1):

measuring point	partial measuring area
1, 2, 3, 4	a
5, 6	b
7, 8	c
9, 10	d
11, 12	e

For an apparatus with more than one fan, additional measuring points shall be positioned on the partial measuring areas a and b, on the centreline between the fans and on straight lines connecting measuring points specified above (see B.2).

6.4.4 Special apparatus

For an apparatus with a fan arrangement and air throw, different from those specified above, the measuring points shall be chosen analogous to the arrangement in the annexes A and B or in accordance with EN ISO 3744.

7 Test procedures

7.1 Measurement of sound pressure / intensity levels

Sound pressure / intensity levels shall be measured with the fan operating at steady state conditions which are considered to be achieved when the fan speed before and after the measurements differs by not more than ± 2 %. The minimum test duration shall be 10 minutes.

NOTE 1 A change in fan speed of 2 % causes a change in sound level of approximately 0,4 dB.

NOTE 2 Generally a period of 30 min is required.

The microphone shall be oriented in such a way that the angle of incidence of the sound waves is the same as that for which the microphone is calibrated.

The measuring period shall be selected in accordance with the chosen method.

When undertaking measurements in accordance with EN ISO 9614-1 the reading for the 8 kHz octave band is accepted.

7.2 Measurement of the background noise

The background noise shall be measured at the center of each partial measuring area with the test subject installed but not operating. The A-weighted overall sound pressure level and the unweighted sound pressure spectrum from 63 Hz to 8000 Hz shall be measured.

The background noise shall be measured immediately before and after testing the apparatus. The average value shall be used.

Auxiliary devices necessary for the operation of the test installation shall be in operation during the measurement of background noise.

7.3 Data to be recorded

The following data shall be measured and recorded as a minimum:

- the reference standard and the method used;
- air temperature and barometric pressure;
- wind velocity at measuring point 1 with the test subject not in operation;
- fan speed setting;
- fan speed before and after the test;
- supply voltage at the motors;
- supply frequency;
- sound pressure or intensity level at the octave band centre frequencies from 63 Hz to 8 000 Hz at all measuring points;
- extraordinary sound events during the measuring period;
- background noise levels.

8 Calculations

8.1 Correction value for the background noise

The correction value for background noise shall be obtained in accordance with EN ISO 3744.

Measurements with differences between the measured values, with the test subject in operation, and the background noise smaller than 6 dB are not valid with the exception of 63 Hz where a difference of 4 dB is acceptable. Where intensity is measured there is no background correction.

NOTE For practical purposes the accuracy of data is less critical at 63 Hz.

8.2 Correction value for the influence of the ambient

The correction value for the influence of the ambient shall be determined in accordance with EN ISO 3744.

8.3 Calculation of sound data

8.3.1 A-weighted sound power level

The A-weighted overall sound power level shall be calculated from the values in the octave bands.

Due to the differences in sound pressure levels and density of measuring points on the partial measuring areas, when measurements in accordance with EN ISO 3744 are being used the calculations in 8.3.2 and 8.3.3 shall apply.

8.3.2 Average sound pressure level on the partial measuring areas a to e

$$L_{pi} = 10 \times lg \left(\frac{1}{n} \times \sum_{k=1}^{n} 10^{0,1 \times (L_{pk} - K_1 - K_2)} \right)_i$$

Where

L_{pi} is average sound pressure level on the partial measuring area number i in dB.

k indicates the measuring points on an individual partial measuring area.

n is the number of measuring points on the individual partial measuring area.

i indicates the individual partial measuring area a to e.

L_{pk} is the sound pressure level at the measuring point on an individual partial measuring area.

K_1 is the correction value for the background noise in dB on the corresponding partial measuring area.

K_2 is the correction value for the influence of the ambient in dB.

NOTE The points within a partial measuring area are chosen such that a simple averaging is possible.

8.3.3 Sound power level of the test subject

$$L_W = 10 \times lg \frac{1}{S_{tot}} \left(\sum_{i=1}^{5} S_i \times 10^{0,1 \times L_{pi}} \right) + 10 \times lg (S_{tot} / S_o)$$

Where

L_W is the sound power level in dB for the test subject.

S_{tot} is the total measuring surface in m^2.

S_i is the content of one of the partial measuring areas a to e in m^2.

L_{pi} is average sound pressure level on the partial measuring area number i in dB.

i indicates the individual partial measuring area a to e.

S_o is the content of the reference area in m^2. $S_o = 1\ m^2$.

9 Conversion to nominal fan speed

Conversion to nominal fan speed shall be not be made.

10 Test report

The test report shall be in accordance with EN ISO/IEC 17025.

Annex A
(normative)

Positions of measuring points for vertical air throw

A.1 Example with one fan

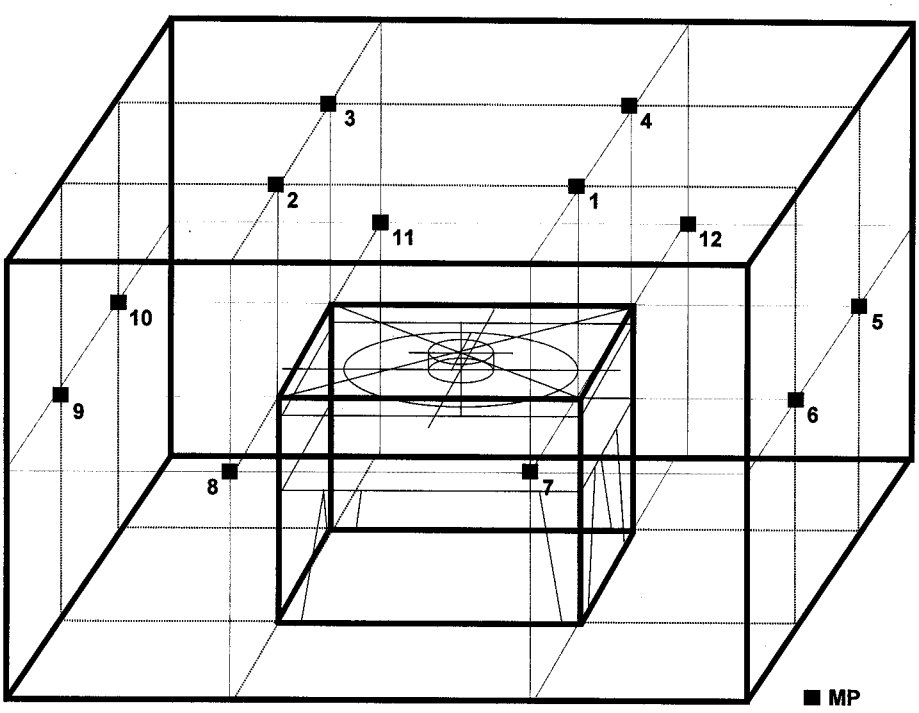

Figure A.1 - 1 fan: 12 measuring points (MP)

A.2 Example with six fans

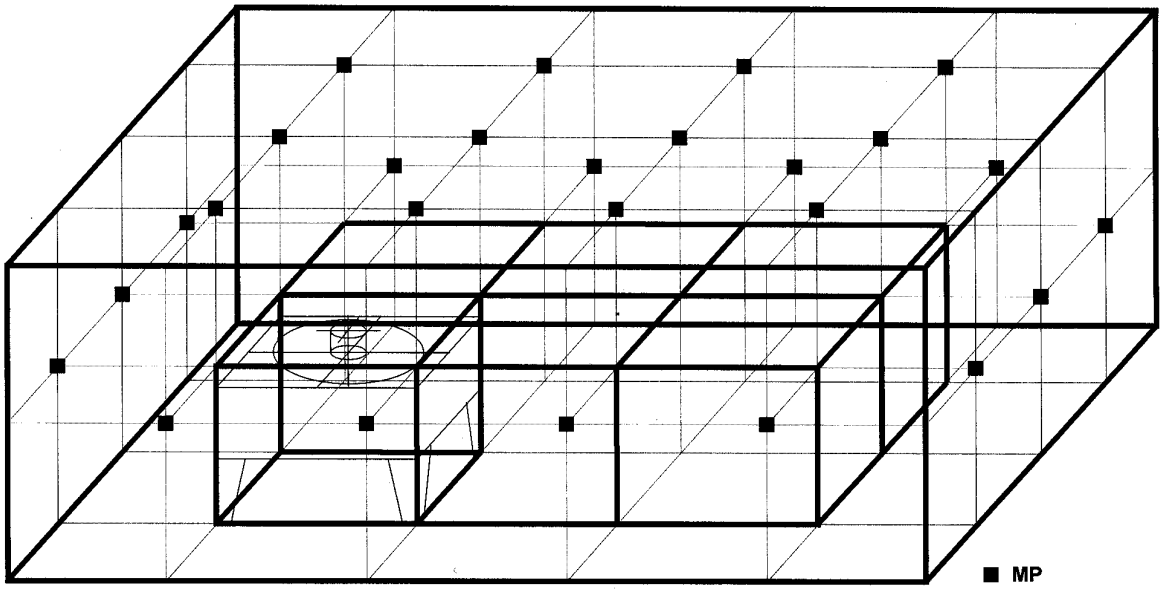

Figure A.2 - 6 fans: 26 measuring points (MP)

Annex B
(normative)

Positions of measuring points for horizontal air throw

B.1 Example with one fan

Dimensions in cm

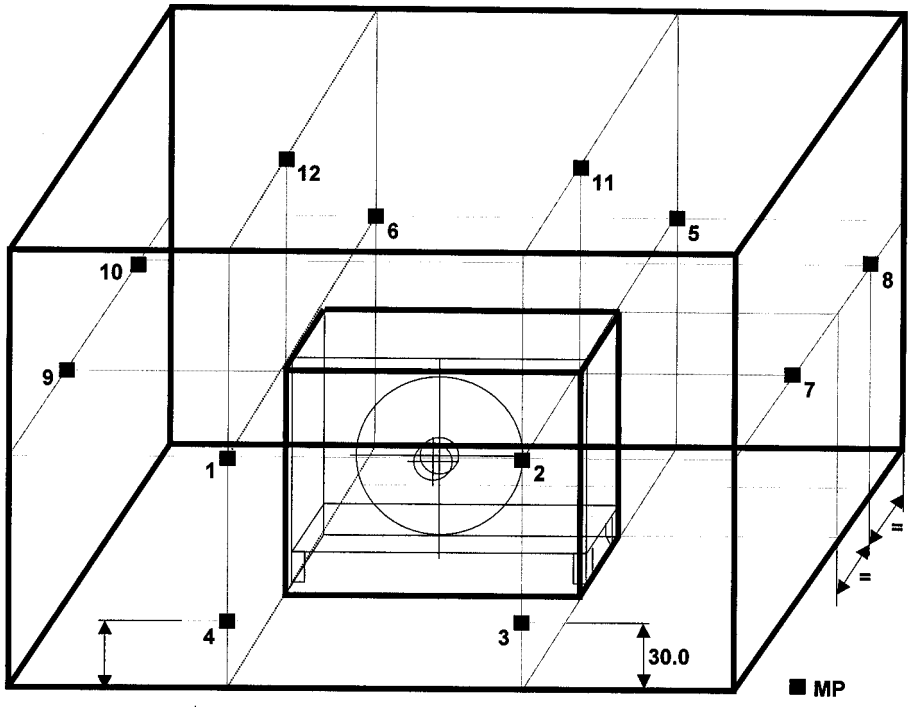

Figure B.1 - 1 fan: 12 measuring points (MP)

B.2 Example with six fans

Dimensions in cm

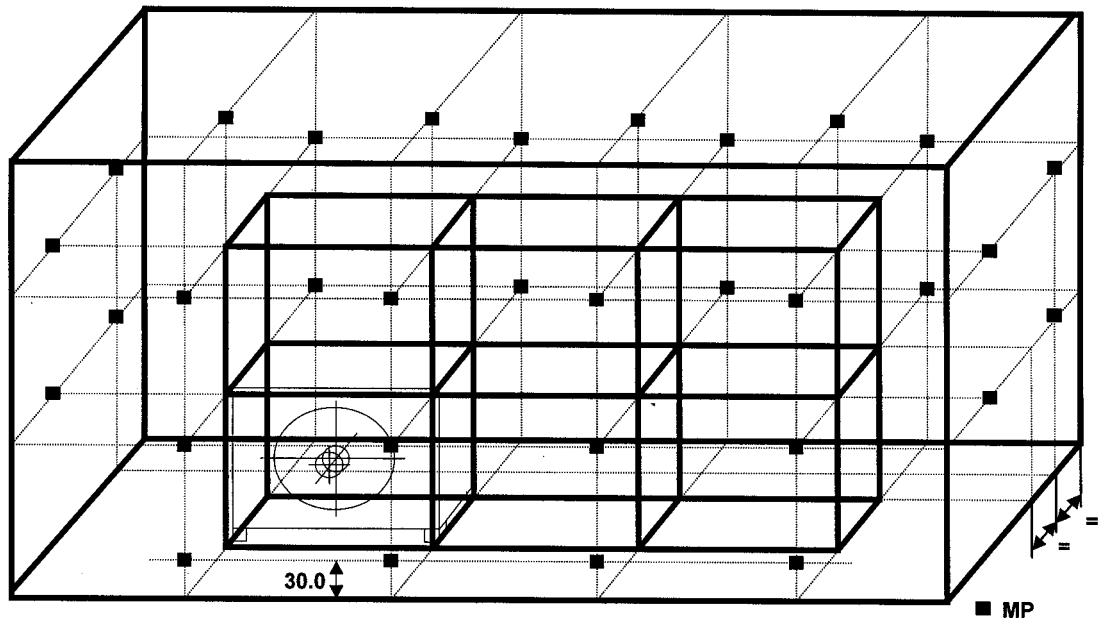

Figure B.2 - 6 fans: 32 measuring points (MP)

Annex C
(normative)

Standard method for calculating the sound pressure level

The standard sound pressure level at a given distance from the apparatus shall be calculated in accordance with the following equation:

$$L_{pd} = L_W - 10 \times lg \left(\frac{S_d}{S_o} \right)$$

Where

L_{pd} is the average sound pressure level on an enveloping area in the shape of a parallelepiped at the distance of d m from the reference box in dB.

L_W is the sound power level of the apparatus

S_d is the content of a parallelepiped shaped enveloping area arranged in a distance of d m around the reference box for the model in m^2.

S_o is the content of the reference area in m^2. $S_o = 1\ m^2$.

If an A-weighted nominal sound pressure level is given, it shall be calculated for a distance of 10 m from the reference box.

Annex D
(normative)

Deviations from the test subject

D.1 Model ranges composed of modules

In the absence of test results the sound power level of one apparatus with n modules may be calculated from the sound power level of the test subject with n_T modules as follows:

$$L_W = L_{WT} + 10 \lg \frac{n}{n_T}$$

Where

L_W is the sound power level for an apparatus composed of n modules in dB

L_{WT} is the sound power level of the test subject composed of n_T modules in dB

n is the number of modules comprising the apparatus

n_T is the number of modules comprising the test subject

D.2 Dimensions of the heat exchanger coil

For equal intake areas the influence of the length and width of the heat exchanger coil on the sound power level can be neglected.

Where differences in the dimensions of the heat exchanger coil (e.g. intake area, depth in direction of air flow, geometry) with the same fan, result in deviations of the air flow rate per module of less than ± 20 % from that of the test subject, no correction is required.

For deviations of more than ± 20 % separate tests should be conducted.

Annex E
(informative)

Directivity

E.1 General

Recognising the difficulties in defining directivity, the following method of calculating a directivity number is specified to give a uniform method of defining a figure that is required by the market.

Where a directivity figure is published, it should be based on the average sound pressure values ascertained on the partial measuring areas and obtained in accordance with the E.2 and E.3.

E.2 Definition

E.2.1
directivity number
difference between the average sound pressure level of the individual partial measuring areas and the average sound pressure level for the whole measuring surface

E.3 Calculation of the directivity number

For the purposes of this standard the directivity number should be calculated as follows:

$$DI_k = L_{pAk} - 10 \times lg \frac{1}{S_{tot}} \left(\sum_{i=1}^{5} S_i \quad 10^{0,1 \times L_{pAi}} \right)$$

Where

Di_k is the A-weighted directivity number in dB for the partial measuring area *k*

L_{pAk} is the average sound pressure level on the partial measuring area *k*.

S_{tot} is the total measuring surface in m^2.

i indicates the partial measuring areas a to e

S_i is the content of one of the partial measuring areas a to e in m^2.

L_{pAi} is the average sound pressure level on the partial measuring areas a to e.

Directivity numbers should not be given without the direction to which they apply.

The directivity numbers will apply to all models composed of the same module.

Bibliography

EN ISO 3740, *Acoustics - Determination of sound power levels of noise sources - Guidelines for the use of basic standards (ISO 3740:2000).*

EN ISO 11203, *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 (ISO 11203:1995).*

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