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COMMENTED VERSION

INTERNATIONAL STANDARD

colour inside

Rotating electrical machines –
Part 9: Noise limits

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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This commented version (CMV) of the official standard IEC 60034-9:2021 edition 5.0 allows the user to identify the changes made to the previous IEC 60034-9:2003 +AMD1:2007 CSV edition 4.1. Futhermore, comments from IEC TC 2 experts are provided to explain the reasons of the most relevant changes.

A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text. Experts' comments are identified by a blue-background number. Mouse over a number to display a pop-up note with the comment.

This publication contains the CMV and the official standard. The full list of comments is available at the end of the CMV.

IEC 60034-9 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This fifth edition cancels and replaces the fourth edition, published in 2003 and its amendment 1, published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) In Table 2 and Table 3 cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 are now covered.
b) This edition adds Table 3 for 60 Hz machines, whereas Table 2, which covers only 50 Hz machines, has no change in levels.
c) In Table 3, grade A is added to harmonize the highest levels seen in IEC and NEMA, whereas grade B was added to harmonize the lowest, more restrictive levels seen in IEC and NEMA.
d) The clause “Determination of noise increments caused by converter supply” has been shifted to Annex B and renamed “Information on typical noise increments caused by converter supply”

The text of this International Standard is based on the following documents:

FDIS	Report on voting
2/2064/FDIS	2/2069/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

Acoustic quantities can be expressed in sound pressure terms or sound power terms. The use of a sound power level, which can be specified independently of the measurement surface and environmental conditions, avoids the complications associated with sound pressure levels, which require additional data to be specified. Sound power levels provide a measure of radiated energy and have advantages in acoustic analysis and design.

ROTATING ELECTRICAL MACHINES –

Part 9: Noise limits

1 Scope

This part of IEC 60034:

– specifies test methods for the determination of sound power level of rotating electrical machines;

– specifies maximum A-weighted sound power levels for factory acceptance testing of network-supplied, rotating electrical machines in accordance with IEC 60034-1, having methods of cooling according to IEC 60034-6 and degrees of protection according to IEC 60034-5, and having the following characteristics:

- standard design, either AC or DC, without additional special electrical, mechanical, or acoustical modifications intended to reduce the sound power level
- rated output from 1 kW (or kVA) up to and including 5 500 kW (or kVA)
- rated speed not greater than 3 750 min^{-1}

~~– provides guidance for the determination of noise levels for a.c. cage induction motors supplied by converters.~~

Excluded are noise limits for AC motors supplied by converters. For these conditions see ~~IEC 60034-17~~ Annex B for guidance.

The object of this document is to determine maximum A-weighted sound power levels, L_{WA} in decibels, dB, for airborne noise emitted by rotating electrical machines of standard design, as a function of power, speed and load, and to specify the method of measurement and the test conditions appropriate for the determination of the sound power level of the machines to provide a standardized evaluation of machine noise up to the maximum specified sound power levels. This document does not provide correction for the existence of tonal characteristics.

Sound pressure levels at a distance from the machine may be required in some applications, such as hearing protection programs. Information is provided on such a procedure in Clause 7 based on a standardized test environment.

NOTE 1 This document recognizes the economic reason for the availability of standard noise-level machines for use in non-critical areas or for use with supplementary means of noise attenuation.

NOTE 2 Where sound power levels lower than those specified in Table 1, Table 2 or Table 3 are required, these ~~should be~~ are agreed between the manufacturer and the purchaser, as special electrical, mechanical, or acoustical design may involve additional measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60034-6, *Rotating electrical machines – Part 6: Methods of cooling (IC Code)*

~~IEC 60034-17, *Rotating electrical machines – Part 17: Cage induction motors when fed from convertors – Application guide*~~

ISO 3741, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms*

ISO 3743-1, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic rooms and ~~semi~~ hemi-anechoic rooms*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 3747, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure ~~– Comparison method in situ~~ Engineering/survey methods for use in situ in a reverberant environment*

ISO 4871, *Acoustics – Declaration and verification of noise emission values of machinery and equipment*

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

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
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 [W_o = 1 pW (10^{-12} W)] expressed in decibels

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 to the square of the reference sound pressure [P_o = 20 μPa (2 × 10^{-5} Pa)] expressed in decibels

3.3
measurement surface index
L_S
ten times the logarithm to the base 10 of the ratio of the measurement surface S to the reference surface [S_0 = 1 m^2] expressed in decibels

3.4
maximum value
value that defines the upper limit without further tolerance

4 Methods of measurement

4.1 Sound pressure level measurements and calculation of sound power level produced by the machine shall be made in accordance with ISO 3744, unless one of the alternative methods specified in 4.3 or 4.4 below applies.

NOTE ~~It is recommended that the hemispherical method be used for machines with shaft height up to 180 mm and the parallelepiped method used for machines larger than 355 mm. Either method may be used for intermediate shaft heights.~~ It is general practice to use the parallelepiped method for all shaft heights. 1

4.2 The maximum sound power levels specified in Table 1, Table 2 and Table 3 or adjusted by Table 4 relate to measurements made in accordance with 4.1.

4.3 When appropriate, one of the methods of precision or engineering grade accuracy, such as the methods of ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3745, ISO 9614-1 or ISO 9614-2, may be used to determine sound power levels.

4.4 The simpler but less accurate method specified in ISO 3746 or ISO 3747 may be used, especially when the environmental conditions required by ISO 3744 cannot be satisfied (for example, for large machines).

However, to prove compliance with this document, unless a correction due to inaccuracy of the measurement has already been applied to the values determined by this method in accordance with ISO 3746 or ISO 3747, the levels of Table 1, Table 2 and Table 3 shall be decreased by 2 dB.

4.5 If testing under rated load conditions, the methods of ISO 9614 are preferred. However, other methods are allowed when the load machine and auxiliary equipment are acoustically isolated or located outside the test environment.

5 Test conditions

5.1 Machine mounting

5.1.1 Precautions

Care should be taken to minimize the transmission and the radiation of structure-borne noise from all mounting elements including the foundation. This can be achieved by the resilient mounting for smaller machines; however, larger machines can usually only be tested under rigid mounting conditions.

Machines tested under load conditions shall be rigidly mounted.

5.1.2 Resilient mounting

The natural frequency of the support system and the machine under test shall be lower than a ~~quarter~~ third 2 of the frequency corresponding to the lowest rotational speed of the machine.

The effective mass of the resilient support shall be not greater than one-tenth of that of the machine under test.

5.1.3 Rigid mounting

The machines shall be rigidly mounted to a surface with dimensions adequate for the machine type (for example by foot or flange fixed in accordance with the manufacturer's instructions). The machine shall not be subject to additional mounting stresses from incorrect shimming or fasteners.

5.2 Test operating conditions

The following test conditions shall apply:

a) The machine shall operate at rated voltage(s), rated frequency or rated speed(s) and with appropriate field current(s) (when applicable). These shall be measured with instruments of an accuracy of 1 % or better.
   - The standard load condition shall be no-load, except for series wound motors.
   - When required, the machine shall be operated at an agreed load condition.

b) Machines shall be tested in their operating position within their specified duty that generates the greatest noise.

c) For an AC motor, the waveform and the degree of unbalance of the supply system shall comply with the requirements of IEC 60034-1.

   NOTE Any increase of voltage (and current) waveform distortion and unbalance will result in an increase of noise.

d) A synchronous motor with adjustable excitation field shall be run with excitation to obtain unity power factor or for large machines tested as a generator.

e) A generator shall be either run as a motor or driven at rated speed with excitation to obtain the rated voltage on open circuit.

f) A machine suitable for more than one speed shall be evaluated over the operating speed range.

g) A motor intended to be reversible shall be operated in both directions unless no difference in sound power level is expected. A unidirectional motor shall be tested in its design direction.

6 Sound power level limits

Where a machine is tested under the conditions specified in Clause 5, the sound power level of the machine shall not exceed the relevant value(s) specified as follows:

a) A machine, other than those specified in b), operating at no-load shall be as specified in Table 1.

b) A single-speed three-phase cage induction motor with cooling classification IC411, IC511, IC611, IC01, IC11, IC21, IC31, IC71 and IC81, at 50 Hz or 60 Hz, shaft heights from 90 up to and including 560, and with rated output not less than 1,0 kW and not exceeding 1 000 kW:
   - operating at no-load shall be as specified in Table 2 and Table 3

- operating at rated load shall be the sum of the values established in Table 2, Table 3 and Table 4
- Grade A in Table 3 is the maximum level that a standard 60 Hz motor shall meet
- Grade B in Table 3 is a reduced level for 60 Hz motors that will meet the more stringent requirements of the end-user
- unless grade B is specifically requested, grade A is to be used as the default noise level for 60 Hz motors.

~~Converter-supplied a.c. machines are excluded from specified limits.~~

NOTE 1 The limits of Table 1, Table 2 and Table 3 recognize class 2 accuracy grade levels of measurement uncertainty and production variations.

NOTE 2 Sound power levels, under full-load condition, are normally higher than those at no-load. Generally, if ventilation noise is predominant the change may be small; but if the electromagnetic noise is predominant the change may be significant.

NOTE 3 The limits are irrespective of the direction of rotation. A machine with a unidirectional ventilator is generally less noisy than one with a bi-directional ventilator. This effect is more significant for high-speed machines, which may be designed for unidirectional operation only.

NOTE 4 For some machines, the limits in Table 1 may not apply for speeds below nominal speed. In such a case, or where the relationship between noise level and load is important, limits should be agreed between the manufacturer and the purchaser.

NOTE 5 For multispeed machines the values in the Table 1 apply.

~~7 Determination of noise increments caused by converter supply~~

~~Noise emissions of electromagnetic origin at the converter supply can be considered as the superposition of:~~

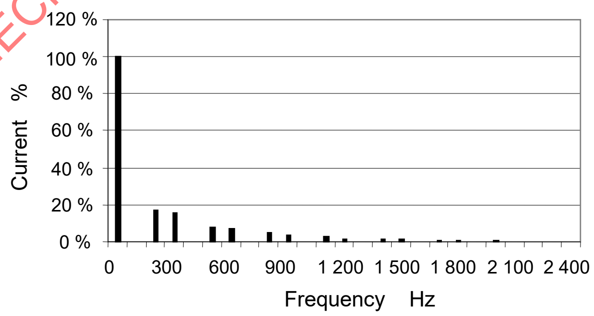
- ~~the noise generated by the voltages and currents of fundamental frequency, which is identical with the noise at sinusoidal supply of the same values, and~~
- ~~an increment caused by voltages and currents at other frequencies.~~

~~Two features mainly influence this increment:~~

~~a) The frequency spectrum at the converter terminals~~

~~Three typical frequency spectra can be identified:~~

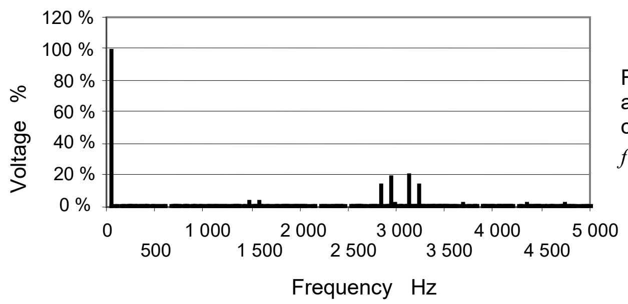
~~1) Spectrum of a block-type current-source converter~~



Frequency spectrum of the currents at the output terminals of a 6-pulse current-source converter
f_1 = 50 Hz

IEC 337/07

~~2) Spectrum of type A voltage-source converter (characterized by pronounced spikes CLOSE to the switching frequency and its multiples)~~

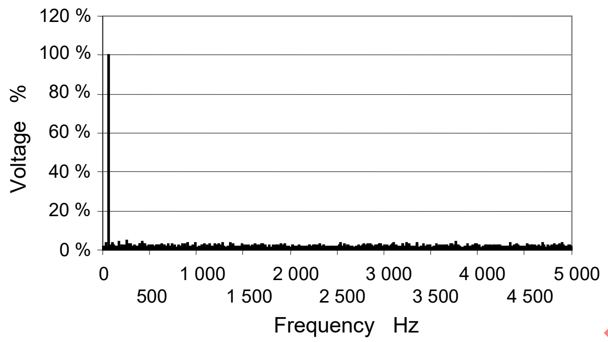


Frequency spectrum of the voltages at the terminals of a type A voltage-source converter

f_1 = 50 Hz, f_s = 3 kHz

IEC 338/07

~~3) Spectrum of type B voltage-source converter (characterized by a broad voltage spectrum without pronounced spikes.)~~



Frequency spectrum of the voltages of a type B voltage-source converter

f_1 = 50 Hz, f_s average = 4,5 kHz

IEC 339/07

~~Specific considerations are necessary when the spectrum deviates significantly from a typical spectrum.~~

~~b) The resonance frequencies of the motor for the modes of vibration caused by the harmonics~~

~~The relevant resonance frequencies of motors can be grouped according to the following table:~~

~~**Shaft height H**~~	~~**Resonance frequencies of vibration mode r**~~			
	~~r = 0~~	~~r = 2~~	~~r = 4~~	~~r = 6~~
~~H ≤ 200 mm~~	~~> 4 000 Hz~~	~~> 600 Hz~~	~~> 4 000 Hz~~	~~> 5 000 Hz~~
~~H ≥ 280 mm~~	~~< 3 000 Hz~~	~~< 500 Hz~~	~~< 2 500 Hz~~	~~< 4 000 Hz~~

~~A magnetically excited tone is generated by the interaction of the fundamental fields of the number of pole-pairs p of the fundamental frequency f_1 at the motor terminals and of one of the harmonic frequencies $n \cdot f_1$, as shown in the relevant frequency spectrum. The tones are of:~~

$$f_r = f_1 \cdot (n \pm 1) = \left\langle \begin{matrix} (n+1) \cdot f_1 \\ (n-1) \cdot f_1 \end{matrix} \right.$$

$$r = p \pm p = \left\langle \begin{matrix} 2p \\ 0 \end{matrix} \right.$$

~~Usually combinations with $n \cdot f_1$, close to the switching frequency generate objectionable tones.~~

~~A reasonable increase of the audible noise is to be expected, if the frequency and the vibration mode of a tone are close to the corresponding values of the resonant structure of the motor. In~~

some cases, objectionable tones may be avoided by changes to the parameter assignment of the converter.

The following table shows the expected increase of noise, at converter supply, when compared to the noise at sinusoidal supply, with the same fundamental values of voltage and frequency.

Increments of noise

Kind of converter	Case	Expected increment
Block-type current-source converter	6-pulse or 12-pulse	1 to 5 dB(A) The higher values relate to motors with low ventilation noise. Increment depends on load.
Type A voltage-source converter	High frequency voltages of high amplitudes excite resonances of the motor	Up to 15 dB(A) Increment does not depend on load. Initial calculation possible by adequate software.
	High frequency voltages of high amplitudes do not excite resonances of the motor	1 to 5 dB(A) Increment does not depend on load.
Type B voltage-source converter	Broad voltage spectrum without pronounced spikes	5 to 10 dB(A) Increment does not depend on load.

7 Determination of sound pressure level

Sound pressure levels are not required as part of this document.

If requested, an A-weighted sound pressure level may be determined directly from the sound power level as follows:

$$L_p = L_W - 10\lg\left(\frac{S}{S_0}\right)$$

where

L_p is the sound pressure level in a free-field over a reflecting plane at 1 m distance from the machine;

L_W is the sound power level determined according to this standard;

S_0 is 1,0 m²;

S is the area of the surface enveloping the machine at a distance from the machine of 1 m according to ISO 3744 and the following rule:

Shaft height	Surface area, S
mm	m²
≤280	Hemisphere
>280	Parallelepiped

However, if requested by end user to provide pressure levels, for example in accordance with Annex A, it shall be per agreement between user and manufacturer. An A-weighted sound pressure level may be determined directly from the sound power level as follows:

$$L_p = L_W - L_S \quad 3$$

$$L_S = 10 \log_{10}\left(\frac{S}{S_0}\right)$$

where:

L_p is the sound pressure level in a free field over a reflecting plane at 1 m distance from the machine;

L_W is the sound power level determined according to this document;

L_S is the measurement surface index;

S_0 is 1,0 m^2;

S is the area of the surface enveloping the machine at a distance of 1 m according to ISO 3744, 7.2.4. (Parallelepiped measurement surface).

NOTE 1 These sound pressure levels are for free field, over a reflecting plane. The sound pressure level for *in situ* conditions (that is, for hearing protection requirements) is different.

NOTE 2 For typical values of the measurement surface index used for conversions from sound power to sound pressure levels for machines in Table 2 and Table 3, see Annex A.

8 Declaration and verification of sound power values

A machine can be declared to comply with this document if, when tested under the conditions specified in Clause 5, the sound power level of the machine does not exceed the value specified in Clause 6.

The method selected and the type of measurement surface used shall be reported.

When requested sound power values determined according to this document can be reported according to the procedures of ISO 4871 using the dual-number presentation (determined sound power level L and uncertainty K).

Values for the uncertainty K are:

a) single machine
   1,5 dB (grade 1: laboratory)
   2,5 dB (grade 2: expertise)
   4,5 dB (grade 3: verification) (confidence 95 %).
b) set of machines of the same batch
   1,5 dB to 4,0 dB (grades 1 and 2)
   4,0 dB to 6,0 dB (grade 3).

Table 1 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load (excluding motors according to Table 2 and Table 3) (Method of cooling, IC code, see IEC 60034-6, Method of protection, IP code, see IEC 60034-5)

Rated speed n_N min^{-1}	$n_N \le 960$			$960 < n_N \le 1\,320$			$1\,320 < n_N \le 1\,900$			$1\,900 < n_N \le 2\,360$			$2\,360 < n_N \le 3\,150$			$3\,150 < n_N \le 3\,750$		
Methods of cooling (simplified code)	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2
Rated output P_N kW (or kVA)																		
$1 \le P_N \le 1{,}1$	73	73	–	76	76	–	77	78	–	79	81	–	81	84	–	82	88	–
$1{,}1 < P_N \le 2{,}2$	74	74	–	78	78	–	81	82	–	83	85	–	85	88	–	86	91	–
$2{,}2 < P_N \le 5{,}5$	77	78	–	81	82	–	85	86	–	86	90	–	89	93	–	93	95	–
$5{,}5 < P_N \le 11$	81	82	–	85	85	–	88	90	–	90	93	–	93	97	–	97	98	–
$11 < P_N \le 22$	84	86	–	88	88	–	91	94	–	93	97	–	96	100	–	97	100	–
$22 < P_N \le 37$	87	90	–	91	91	–	94	98	–	96	100	–	99	102	–	101	102	–
$37 < P_N \le 55$	90	93	–	94	94	–	97	100	–	98	102	–	101	104	–	103	104	–
$55 < P_N \le 110$	93	96	–	97	98	–	100	103	–	101	104	–	103	106	–	105	106	–
$110 < P_N \le 220$	97	99	–	100	102	–	103	106	–	103	107	–	105	109	–	107	110	–
$220 < P_N \le 550$	99	102	98	103	105	100	106	108	102	106	109	102	107	111	102	110	113	105
$550 < P_N \le 1\,100$	101	105	100	106	108	103	108	111	104	108	111	104	109	112	104	111	116	106
$1\,100 < P_N \le 2\,200$	103	107	102	108	110	105	109	113	105	109	113	105	110	113	105	112	118	107
$2200 < P_N \le 5\,500$	105	109	104	110	112	106	110	115	106	111	115	107	112	115	107	114	120	109

NOTE 1 Typical enclosure classification IP22 or IP23.

NOTE 2 Typical enclosure classification IP44 or IP55.

Table 2 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load, 50 Hz, sinusoidal supply (for single speed three-phase cage induction motors ~~IC411, IC511, IC611~~)

	IC411, IC511, IC611				IC01, IC11, IC21 IC31, IC71, IC81			
Shaft height, *H* in mm (NEMA frame number)	**2 pole**	**4 pole**	**6 pole**	**8 pole**	**2 pole**	**4 pole**	**6 pole**	**8 pole**
90 (140)	78	66	63	63	85	73	67	67
100 (N.A.)	82	70	64	64	89	77	68	68
112 (180)	83	72	70	70	90	79	74	74
132 (210)	85	75	73	71	92	82	77	75
160 (250)	87	77	73	72	94	84	77	76
180 (280)	88	80	77	76	95	87	81	80
200 (320)	90	83	80	79	97	90	84	83
225 (360)	92	84	80	79	99	91	84	83
250 (400)	92	85	82	80	99	92	86	84
280 (440)	94	88	85	82	101	95	89	86
315 (500)	98	94	89	88	105	101	93	92
355 (580)	100	95	94	92	107	102	98	96
400 (N.A.)	100	96	95	94	107	103	99	98
450 (680)	100	98	98	96	107	105	102	100
500 (800)	103	99	98	97	110	106	102	101
560 (N.A.)	105	100	99	98	112	107	103	102

NOTE 1 ~~Motors of IC01, IC11, IC21 may have higher sound-power levels as follows: 2 and 4 poles: + 7 dB(A); 6 and 8 poles: + 4 dB(A).~~ Values combine the cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 within one limit.

NOTE 2 The sound-power levels for 2 and 4 pole motors with shaft heights > 315 mm recognize a directional fan configuration. All other values are for bi-directional fans.

NOTE 3 ~~Values for 60 Hz motors are increased as follows: 2 pole: + 5 dB(A); 4, 6 and 8 poles: + 3 dB(A).~~ NEMA frame number is defined in NEMA MG 1.

Table 3 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load, 60 Hz, sinusoidal supply (for single speed three-phase cage induction motors) 4

	IC411, IC511, IC611								IC01, IC11, IC21 IC31, IC71, IC81							
Shaft height, *H* in mm (NEMA frame number)	2 pole		4 pole		6 pole		8 pole		2 pole		4 pole		6 pole		8 pole	
	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B
90 (140)	85	83	70	69	66	64	69	66	90	76	76	70	70	65	70	69
100 (N.A.)	88	87	74	73	67	67	69	67	94	76	80	72	71	67	71	69
112 (180)	88	88	75	74	73	67	73	69	95	80	82	72	77	67	77	69
132 (210)	91	90	79	78	76	71	74	72	97	82	85	76	80	72	78	70
160 (250)	94	92	84	80	76	75	76	75	99	84	87	80	80	76	79	73
180 (280)	94	93	88	83	80	80	80	79	100	86	90	80	84	81	83	76
200 (320)	100	95	89	86	83	83	83	82	102	89	93	84	87	83	86	79
225 (360)	101	97	95	87	86	83	86	82	104	94	94	86	87	86	86	81
250 (400)	102	97	98	88	90	85	89	83	104	98	95	89	89	88	87	84
280 (440)	107	99	105	91	100	88	97	85	107	106	103	98	99	92	95	87
315 (500)	113	103	108	97	103	92	100	91	111	110	108	104	102	96	98	95
355 (580)	116	105	111	98	106	97	102	95	112	112	109	105	107	101	101	99
400 (N.A.)	116	105	111	99	106	98	102	97	112	112	110	106	107	102	101	101
450 (680)	116	105	113	101	106	101	105	99	114	112	110	108	107	105	103	101
500 (800)	118	108	113	102	108	101	107	100	115	114	110	109	109	105	107	104
560 (N.A.)	118	110	113	103	109	102	107	101	117	114	110	110	109	106	107	105

NOTE 1 Values combine the cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 within one limit.

NOTE 2 The sound-power levels for 2 and 4 pole motors with shaft heights > 315 mm recognize a directional fan configuration. All other values are for bi-directional fans.

NOTE 3 NEMA frame number is defined in NEMA MG 1.

Table 4 – ~~Maximum~~ Expected increase, over no-load condition, in A-weighted sound power levels, ΔL_{WA} in dB, for rated load condition (for motors according to Table 2 and Table 3)

Shaft height, *H* mm	2 pole	4 pole	6 pole	8 pole
90 ≤ *H* ≤ 160	2	5	7	8
180 ≤ *H* ≤ 200	2	4	6	7
225 ≤ *H* ≤ 280	2	3	6	7
H = 315	2	3	5	6
355 ≤ *H*	2	2	4	5

NOTE 1 This table gives the ~~maximum~~ expected increase at rated load condition to be added to any declared no-load value.

NOTE 2 This table does not give guaranteed values. Values can be different for various machines and manufacturers.

NOTE ~~2~~ 3 The values apply to both 50 Hz and 60 Hz supplies.

Annex A
(informative)

Typical values for measurement surface index 5

Table A.1 – Typical values for measurement surface index for the conversion from sound power level to sound pressure level based on using parallelepiped measurement surface according to ISO 3744

$$L_S = 10\log_{10}\left(\frac{S}{S_0}\right)$$

Shaft height, H mm (NEMA frame number)	L_S dB
90 (140)	12
100 (N.A.)	12
112 (180)	12
132 (210)	12
160 (250)	12
180 (280)	13
200 (320)	13
225 (360)	13
250 (400)	14
280 (440)	14
315 (500)	14
355 (580)	15
400 (N.A.)	16
450 (680)	16
500 (800)	17
560 (N.A.)	17
NOTE The values above are only for guidance and are not used for sound power level determination according to ISO 3744 or other relevant standards.	

Annex B
(informative)

Information on typical noise increments caused by converter supply

Noise emissions of electromagnetic origin at the converter supply can be considered as the superposition of:

- the noise generated by the voltages and currents of fundamental frequency, which is identical with the noise at sinusoidal supply of the same values, and
- an increment caused by voltages and currents at other frequencies.

Two features mainly influence this increment:

a) The frequency spectrum at the converter terminals

Three typical frequency spectra can be identified in Figure B.1, Figure B.2 and Figure B.3.

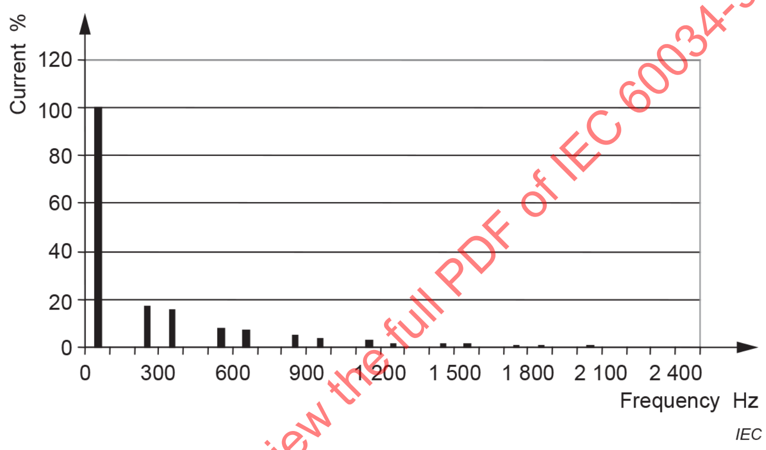


Figure B.1 – Frequency spectrum of the currents at the output terminals of a 6-pulse block-type current-source converter f_1 = 50 Hz

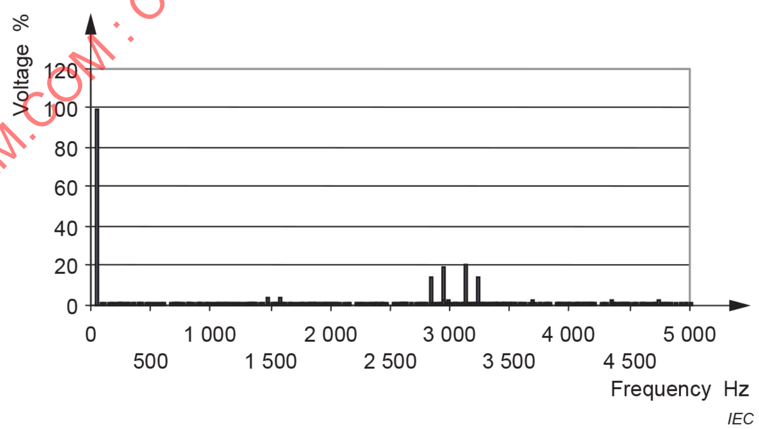


Figure B.2 – Frequency spectrum of the voltages at the terminals of a type A voltage-source converter (characterized by pronounced spikes close to the switching frequency and its multiples) f_1 = 50 Hz, f_s = 3 kHz

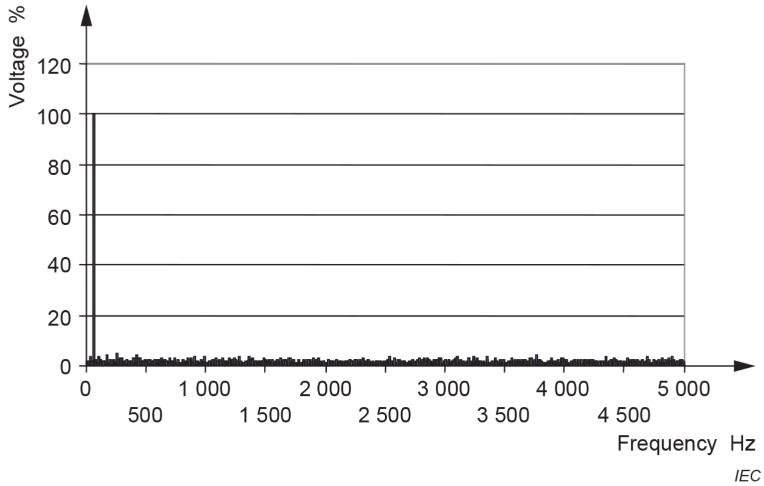


Figure B.3 – Frequency spectrum of the voltages of a type B voltage-source converter (characterized by a broad voltage spectrum without pronounced spikes) f_1 = 50 Hz, f_s average = 4,5 kHz

Specific considerations are necessary when the spectrum deviates significantly from a typical spectrum.

b) Typical values, historically based, for resonance frequencies of the motor for the modes of vibration caused by the harmonics

The relevant resonance frequencies of motors can be grouped according to Table B.1.

Table B.1 – Resonance frequencies of vibration mode r

Shaft height H	Resonance frequencies of vibration mode r			
	r = 0	r = 2	r = 4	r = 6
$H \leq$ 200 mm	> 4 000 Hz	> 600 Hz	> 4 000 Hz	> 5 000 Hz
$H \geq$ 280 mm	< 3 000 Hz	< 500 Hz	< 2 500 Hz	< 4 000 Hz

A magnetically excited tone is generated by the interaction of the fundamental fields of the number of pole pairs p of the fundamental frequency f_1 at the motor terminals and of one of the harmonic frequencies $n \times f_1$, as shown in the relevant frequency spectrum. The tones are of:

frequencies

$$f_r = f_1 \times (n \pm 1) = \begin{cases}(n+1) \times f_1 \\ (n-1) \times f_1\end{cases}$$

vibration modes

$$r = p \pm p = \begin{cases}2p \\ 0\end{cases}$$

Usually combinations with $n \times f_1$, close to the switching frequency generate objectionable tones.

A reasonable increase of the audible noise is to be expected, if the frequency and the vibration mode of a tone are close to the corresponding values of the resonant structure of the motor. In some cases, objectionable tones may be avoided by changes to the parameter assignment of the converter.

Table B.2 shows the typical increase of noise, at converter supply, when compared to the noise at sinusoidal supply, with the same fundamental values of voltage and frequency.

Table B.2 – Increments of A-weighted noise values

Kind of converter	Case	Expected increment
Block-type current-source converter	6-pulse or 12-pulse	1 dB to 5 dB The higher values relate to motors with low ventilation noise. Increment depends on load.
Type A voltage-source converter	High frequency voltages of high amplitudes excite resonances of the motor	Up to 15 dB Increment does not depend on load. Initial calculation possible by adequate software.
	High frequency voltages of high amplitudes do not excite resonances of the motor	1 dB to 5 dB Increment does not depend on load.
Type B voltage-source converter	Broad voltage spectrum without pronounced spikes	5 dB to 10 dB Increment does not depend on load.

Bibliography

IEC TS 60034-25, *Rotating electrical machines – Part 25: AC electrical machines used in power drive system – Application guide*

ISO 1680, *Acoustics – Test code for the measurement of airborne noise emitted by rotating electrical machines*

ISO 80000-8, *Quantities and units – Part 8: Acoustics*

NEMA MG 1, *Motors and Generators – Part 9: Rotating Electrical Machines – Sound Power Limits and Measurement Procedures*

List of comments

1 The values of L_S in Table A.1 are given only for parallelepiped surface.

2 This modification was done as to make this standard in-line with IEC 60034-14.

3 It is now specified, how to convert sound power levels to sound pressure levels. However, the limits apply still only to sound power levels.

4 Table 3 was added in order to harmonize this standard with NEMA.

5 For user's convenience, this table was added to give typical values for L_S.

IEC 60034-9

Edition 5.0 2021-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Rotating electrical machines –
Part 9: Noise limits**

**Machines électriques tournantes –
Partie 9: Limites de bruit**

IEC 60034-9:2021-10(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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ROTATING ELECTRICAL MACHINES –

Part 9: Noise limits

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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IEC 60034-9 has been prepared by IEC technical committee 2: Rotating machinery. It is an International Standard.

This fifth edition cancels and replaces the fourth edition, published in 2003 and its amendment 1, published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) In Table 2 and Table 3 cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 are now covered.
b) This edition adds Table 3 for 60 Hz machines, whereas Table 2, which covers only 50 Hz machines, has no change in levels.
c) In Table 3, grade A is added to harmonize the highest levels seen in IEC and NEMA, whereas grade B was added to harmonize the lowest, more restrictive levels seen in IEC and NEMA.

d) The clause "Determination of noise increments caused by converter supply" has been shifted to Annex B and renamed "Information on typical noise increments caused by converter supply"

The text of this International Standard is based on the following documents:

FDIS	Report on voting
2/2064/FDIS	2/2069/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

A list of all parts in the IEC 60034 series, published under the general title *Rotating electrical machines*, can be found on the IEC website.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

Acoustic quantities can be expressed in sound pressure terms or sound power terms. The use of a sound power level, which can be specified independently of the measurement surface and environmental conditions, avoids the complications associated with sound pressure levels, which require additional data to be specified. Sound power levels provide a measure of radiated energy and have advantages in acoustic analysis and design.

ROTATING ELECTRICAL MACHINES –

Part 9: Noise limits

1 Scope

This part of IEC 60034:

– specifies test methods for the determination of sound power level of rotating electrical machines;

– specifies maximum A-weighted sound power levels for factory acceptance testing of network-supplied, rotating electrical machines in accordance with IEC 60034-1, having methods of cooling according to IEC 60034-6 and degrees of protection according to IEC 60034-5, and having the following characteristics:

- standard design, either AC or DC, without additional special electrical, mechanical, or acoustical modifications intended to reduce the sound power level
- rated output from 1 kW (or kVA) up to and including 5 500 kW (or kVA)
- rated speed not greater than 3 750 min^{-1}

Excluded are noise limits for AC motors supplied by converters. For these conditions see Annex B for guidance.

The object of this document is to determine maximum A-weighted sound power levels, L_{WA} in decibels, dB, for airborne noise emitted by rotating electrical machines of standard design, as a function of power, speed and load, and to specify the method of measurement and the test conditions appropriate for the determination of the sound power level of the machines to provide a standardized evaluation of machine noise up to the maximum specified sound power levels. This document does not provide correction for the existence of tonal characteristics.

Sound pressure levels at a distance from the machine may be required in some applications, such as hearing protection programs. Information is provided on such a procedure in Clause 7 based on a standardized test environment.

NOTE 1 This document recognizes the economic reason for the availability of standard noise-level machines for use in non-critical areas or for use with supplementary means of noise attenuation.

NOTE 2 Where sound power levels lower than those specified in Table 1, Table 2 or Table 3 are required, these are agreed between the manufacturer and the purchaser, as special electrical, mechanical, or acoustical design may involve additional measures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60034-1, *Rotating electrical machines – Part 1: Rating and performance*

IEC 60034-5, *Rotating electrical machines – Part 5: Degrees of protection provided by the integral design of rotating electrical machines (IP code) – Classification*

IEC 60034-6, *Rotating electrical machines – Part 6: Methods of cooling (IC Code)*

ISO 3741, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for reverberation test rooms*

ISO 3743-1, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 1: Comparison method for a hard-walled test room*

ISO 3743-2, *Acoustics – Determination of sound power levels of noise sources using sound pressure – Engineering methods for small, movable sources in reverberant fields – Part 2: Methods for special reverberation test rooms*

ISO 3744, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3745, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Precision methods for anechoic rooms and hemi-anechoic rooms*

ISO 3746, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

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*

ISO 4871, *Acoustics – Declaration and verification of noise emission values of machinery and equipment*

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

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

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
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 [W_o = 1 pW (10^{-12} W)] expressed in decibels

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 to the square of the reference sound pressure [P_o = 20 μPa (2 × 10^{-5} Pa)] expressed in decibels

3.3
measurement surface index
L_S
ten times the logarithm to the base 10 of the ratio of the measurement surface S to the reference surface [S_0 = 1 m^2] expressed in decibels

3.4
maximum value
value that defines the upper limit without further tolerance

4 Methods of measurement

4.1 Sound pressure level measurements and calculation of sound power level produced by the machine shall be made in accordance with ISO 3744, unless one of the alternative methods specified in 4.3 or 4.4 below applies.

NOTE It is general practice to use the parallelepiped method for all shaft heights.

4.2 The maximum sound power levels specified in Table 1, Table 2 and Table 3 or adjusted by Table 4 relate to measurements made in accordance with 4.1.

4.3 When appropriate, one of the methods of precision or engineering grade accuracy, such as the methods of ISO 3741, ISO 3743-1, ISO 3743-2, ISO 3745, ISO 9614-1 or ISO 9614-2, may be used to determine sound power levels.

4.4 The simpler but less accurate method specified in ISO 3746 or ISO 3747 may be used, especially when the environmental conditions required by ISO 3744 cannot be satisfied (for example, for large machines).

However, to prove compliance with this document, unless a correction due to inaccuracy of the measurement has already been applied to the values determined by this method in accordance with ISO 3746 or ISO 3747, the levels of Table 1, Table 2 and Table 3 shall be decreased by 2 dB.

4.5 If testing under rated load conditions, the methods of ISO 9614 are preferred. However, other methods are allowed when the load machine and auxiliary equipment are acoustically isolated or located outside the test environment.

5 Test conditions

5.1 Machine mounting

5.1.1 Precautions

Care should be taken to minimize the transmission and the radiation of structure-borne noise from all mounting elements including the foundation. This can be achieved by the resilient mounting for smaller machines; however, larger machines can usually only be tested under rigid mounting conditions.

Machines tested under load conditions shall be rigidly mounted.

5.1.2 Resilient mounting

The natural frequency of the support system and the machine under test shall be lower than a third of the frequency corresponding to the lowest rotational speed of the machine.

The effective mass of the resilient support shall be not greater than one-tenth of that of the machine under test.

5.1.3 Rigid mounting

The machines shall be rigidly mounted to a surface with dimensions adequate for the machine type (for example by foot or flange fixed in accordance with the manufacturer's instructions). The machine shall not be subject to additional mounting stresses from incorrect shimming or fasteners.

5.2 Test operating conditions

The following test conditions shall apply:

a) The machine shall operate at rated voltage(s), rated frequency or rated speed(s) and with appropriate field current(s) (when applicable). These shall be measured with instruments of an accuracy of 1 % or better.
   – The standard load condition shall be no-load, except for series wound motors.
   – When required, the machine shall be operated at an agreed load condition.

b) Machines shall be tested in their operating position within their specified duty that generates the greatest noise.

c) For an AC motor, the waveform and the degree of unbalance of the supply system shall comply with the requirements of IEC 60034-1.

   NOTE Any increase of voltage (and current) waveform distortion and unbalance will result in an increase of noise.

d) A synchronous motor with adjustable excitation field shall be run with excitation to obtain unity power factor or for large machines tested as a generator.

e) A generator shall be either run as a motor or driven at rated speed with excitation to obtain the rated voltage on open circuit.

f) A machine suitable for more than one speed shall be evaluated over the operating speed range.

g) A motor intended to be reversible shall be operated in both directions unless no difference in sound power level is expected. A unidirectional motor shall be tested in its design direction.

6 Sound power level limits

Where a machine is tested under the conditions specified in Clause 5, the sound power level of the machine shall not exceed the relevant value(s) specified as follows:

a) A machine, other than those specified in b), operating at no-load shall be as specified in Table 1.

b) A single-speed three-phase cage induction motor with cooling classification IC411, IC511, IC611, IC01, IC11, IC21, IC31, IC71 and IC81, at 50 Hz or 60 Hz, shaft heights from 90 up to and including 560, and with rated output not less than 1,0 kW and not exceeding 1 000 kW:
   - operating at no-load shall be as specified in Table 2 and Table 3
   - operating at rated load shall be the sum of the values established in Table 2, Table 3 and Table 4
   - Grade A in Table 3 is the maximum level that a standard 60 Hz motor shall meet

- Grade B in Table 3 is a reduced level for 60 Hz motors that will meet the more stringent requirements of the end-user
- unless grade B is specifically requested, grade A is to be used as the default noise level for 60 Hz motors.

NOTE 1 The limits of Table 1, Table 2 and Table 3 recognize class 2 accuracy grade levels of measurement uncertainty and production variations.

NOTE 2 Sound power levels, under full-load condition, are normally higher than those at no-load. Generally, if ventilation noise is predominant the change may be small; but if the electromagnetic noise is predominant the change may be significant.

NOTE 3 The limits are irrespective of the direction of rotation. A machine with a unidirectional ventilator is generally less noisy than one with a bi-directional ventilator. This effect is more significant for high-speed machines, which may be designed for unidirectional operation only.

NOTE 4 For some machines, the limits in Table 1 may not apply for speeds below nominal speed. In such a case, or where the relationship between noise level and load is important, limits should be agreed between the manufacturer and the purchaser.

NOTE 5 For multispeed machines the values in the Table 1 apply.

7 Determination of sound pressure level

Sound pressure levels are not required as part of this document.

However, if requested by end user to provide pressure levels, for example in accordance with Annex A, it shall be per agreement between user and manufacturer. An A-weighted sound pressure level may be determined directly from the sound power level as follows:

$$L_\mathrm{p} = L_\mathrm{W} - L_\mathrm{S}$$

$$L_\mathrm{S} = 10\log_{10}\left(\frac{S}{S_0}\right)$$

where:

L_p is the sound pressure level in a free field over a reflecting plane at 1 m distance from the machine;

L_W is the sound power level determined according to this document;

L_S is the measurement surface index;

S_0 is 1,0 m^2;

S is the area of the surface enveloping the machine at a distance of 1 m according to ISO 3744, 7.2.4. (Parallelepiped measurement surface).

NOTE 1 These sound pressure levels are for free field, over a reflecting plane. The sound pressure level for *in situ* conditions (that is, for hearing protection requirements) is different.

NOTE 2 For typical values of the measurement surface index used for conversions from sound power to sound pressure levels for machines in Table 2 and Table 3, see Annex A.

8 Declaration and verification of sound power values

A machine can be declared to comply with this document if, when tested under the conditions specified in Clause 5, the sound power level of the machine does not exceed the value specified in Clause 6.

The method selected and the type of measurement surface used shall be reported.

When requested sound power values determined according to this document can be reported according to the procedures of ISO 4871 using the dual-number presentation (determined sound power level L and uncertainty K).

Values for the uncertainty K are:

a) single machine

   1,5 dB (grade 1: laboratory)

   2,5 dB (grade 2: expertise)

   4,5 dB (grade 3: verification) (confidence 95 %).

b) set of machines of the same batch

   1,5 dB to 4,0 dB (grades 1 and 2)

   4,0 dB to 6,0 dB (grade 3).

Table 1 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load (excluding motors according to Table 2 and Table 3) (Method of cooling, IC code, see IEC 60034-6, Method of protection, IP code, see IEC 60034-5)

Rated speed n_N min^{-1}	n_N ≤ 960			960 < n_N ≤ 1 320			1 320 < n_N ≤ 1 900			1 900 < n_N ≤ 2 360			2 360 < n_N ≤ 3 150			3 150 < n_N ≤ 3 750		
Methods of cooling (simplified code)	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2	IC01 IC11 IC21 NOTE 1	IC411 IC511 IC611 NOTE 2	IC31 IC71W IC81W IC8A1W7 NOTE 2
Rated output P_N kW (or kVA)																		
1≤P_N≤1,1	73	73	–	76	76	–	77	78	–	79	81	–	81	84	–	82	88	–
1,1<P_N≤2,2	74	74	–	78	78	–	81	82	–	83	85	–	85	88	–	86	91	–
2,2<P_N≤5,5	77	78	–	81	82	–	85	86	–	86	90	–	89	93	–	93	95	–
5,5<P_N≤11	81	82	–	85	85	–	88	90	–	90	93	–	93	97	–	97	98	–
11<P_N≤22	84	86	–	88	88	–	91	94	–	93	97	–	96	100	–	97	100	–
22<P_N≤37	87	90	–	91	91	–	94	98	–	96	100	–	99	102	–	101	102	–
37<P_N≤55	90	93	–	94	94	–	97	100	–	98	102	–	101	104	–	103	104	–
55<P_N≤110	93	96	–	97	98	–	100	103	–	101	104	–	103	106	–	105	106	–
110<P_N≤220	97	99	–	100	102	–	103	106	–	103	107	–	105	109	–	107	110	–
220<P_N≤550	99	102	98	103	105	100	106	108	102	106	109	102	107	111	102	110	113	105
550<P_N≤1 100	101	105	100	106	108	103	108	111	104	108	111	104	109	112	104	111	116	106
1 100<P_N≤2 200	103	107	102	108	110	105	109	113	105	109	113	105	110	113	105	112	118	107
2200<P_N≤5 500	105	109	104	110	112	106	110	115	106	111	115	107	112	115	107	114	120	109

NOTE 1 Typical enclosure classification IP22 or IP23.

NOTE 2 Typical enclosure classification IP44 or IP55.

Table 2 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load, 50 Hz, sinusoidal supply (for single speed three-phase cage induction motors)

	IC411, IC511, IC611				IC01, IC11, IC21 IC31, IC71, IC81			
Shaft height, H in mm (NEMA frame number)	**2 pole**	**4 pole**	**6 pole**	**8 pole**	**2 pole**	**4 pole**	**6 pole**	**8 pole**
90 (140)	78	66	63	63	85	73	67	67
100 (N.A.)	82	70	64	64	89	77	68	68
112 (180)	83	72	70	70	90	79	74	74
132 (210)	85	75	73	71	92	82	77	75
160 (250)	87	77	73	72	94	84	77	76
180 (280)	88	80	77	76	95	87	81	80
200 (320)	90	83	80	79	97	90	84	83
225 (360)	92	84	80	79	99	91	84	83
250 (400)	92	85	82	80	99	92	86	84
280 (440)	94	88	85	82	101	95	89	86
315 (500)	98	94	89	88	105	101	93	92
355 (580)	100	95	94	92	107	102	98	96
400 (N.A.)	100	96	95	94	107	103	99	98
450 (680)	100	98	98	96	107	105	102	100
500 (800)	103	99	98	97	110	106	102	101
560 (N.A.)	105	100	99	98	112	107	103	102

NOTE 1 Values combine the cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 within one limit.

NOTE 2 The sound-power levels for 2 and 4 pole motors with shaft heights > 315 mm recognize a directional fan configuration. All other values are for bi-directional fans.

NOTE 3 NEMA frame number is defined in NEMA MG 1.

Table 3 – Maximum A-weighted sound power level, L_{WA} in dB, at no-load, 60 Hz, sinusoidal supply (for single speed three-phase cage induction motors)

	IC411, IC511, IC611								IC01, IC11, IC21 IC31, IC71, IC81							
Shaft height, *H* in mm (NEMA frame number)	2 pole		4 pole		6 pole		8 pole		2 pole		4 pole		6 pole		8 pole	
	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B	grade A	grade B
90 (140)	85	83	70	69	66	64	69	66	90	76	76	70	70	65	70	69
100 (N.A.)	88	87	74	73	67	67	69	67	94	76	80	72	71	67	71	69
112 (180)	88	88	75	74	73	67	73	69	95	80	82	72	77	67	77	69
132 (210)	91	90	79	78	76	71	74	72	97	82	85	76	80	72	78	70
160 (250)	94	92	84	80	76	75	76	75	99	84	87	80	80	76	79	73
180 (280)	94	93	88	83	80	80	80	79	100	86	90	80	84	81	83	76
200 (320)	100	95	89	86	83	83	83	82	102	89	93	84	87	83	86	79
225 (360)	101	97	95	87	86	83	86	82	104	94	94	86	87	86	86	81
250 (400)	102	97	98	88	90	85	89	83	104	98	95	89	89	88	87	84
280 (440)	107	99	105	91	100	88	97	85	107	106	103	98	99	92	95	87
315 (500)	113	103	108	97	103	92	100	91	111	110	108	104	102	96	98	95
355 (580)	116	105	111	98	106	97	102	95	112	112	109	105	107	101	101	99
400 (N.A.)	116	105	111	99	106	98	102	97	112	112	110	106	107	102	101	101
450 (680)	116	105	113	101	106	101	105	99	114	112	110	108	107	105	103	101
500 (800)	118	108	113	102	108	101	107	100	115	114	110	109	109	105	107	104
560 (N.A.)	118	110	113	103	109	102	107	101	117	114	110	110	109	106	107	105

NOTE 1 Values combine the cooling methods IC01, IC11, IC21 and IC31, IC71, IC81 within one limit.

NOTE 2 The sound-power levels for 2 and 4 pole motors with shaft heights > 315 mm recognize a directional fan configuration. All other values are for bi-directional fans.

NOTE 3 NEMA frame number is defined in NEMA MG 1.

Table 4 – Expected increase, over no-load condition, in A-weighted sound power levels, ΔL_{WA} in dB, for rated load condition (for motors according to Table 2 and Table 3)

Shaft height, ***H*** mm	**2 pole**	**4 pole**	**6 pole**	**8 pole**
$90 \leq H \leq 160$	2	5	7	8
$180 \leq H \leq 200$	2	4	6	7
$225 \leq H \leq 280$	2	3	6	7
$H = 315$	2	3	5	6
$355 \leq H$	2	2	4	5

NOTE 1 This table gives the expected increase at rated load condition to be added to any declared no-load value.

NOTE 2 This table does not give guaranteed values. Values can be different for various machines and manufacturers.

NOTE 3 The values apply to both 50 Hz and 60 Hz supplies.

Annex A
(informative)

Typical values for measurement surface index

Table A.1 – Typical values for measurement surface index for the conversion from sound power level to sound pressure level based on using parallelepiped measurement surface according to ISO 3744

$$L_S = 10 \log_{10} \left(\frac{S}{S_0}\right)$$

Shaft height, H mm (NEMA frame number)	L_S dB
90 (140)	12
100 (N.A.)	12
112 (180)	12
132 (210)	12
160 (250)	12
180 (280)	13
200 (320)	13
225 (360)	13
250 (400)	14
280 (440)	14
315 (500)	14
355 (580)	15
400 (N.A.)	16
450 (680)	16
500 (800)	17
560 (N.A.)	17

NOTE The values above are only for guidance and are not used for sound power level determination according to ISO 3744 or other relevant standards.

Annex B
(informative)

Information on typical noise increments caused by converter supply

Noise emissions of electromagnetic origin at the converter supply can be considered as the superposition of:

- the noise generated by the voltages and currents of fundamental frequency, which is identical with the noise at sinusoidal supply of the same values, and
- an increment caused by voltages and currents at other frequencies.

Two features mainly influence this increment:

a) The frequency spectrum at the converter terminals

Three typical frequency spectra can be identified in Figure B.1, Figure B.2 and Figure B.3.

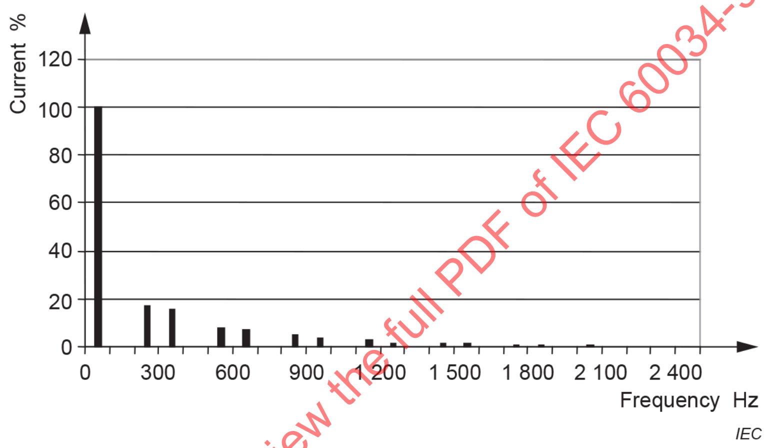

Figure B.1 – Frequency spectrum of the currents at the output terminals of a 6-pulse block-type current-source converter f_1 = 50 Hz

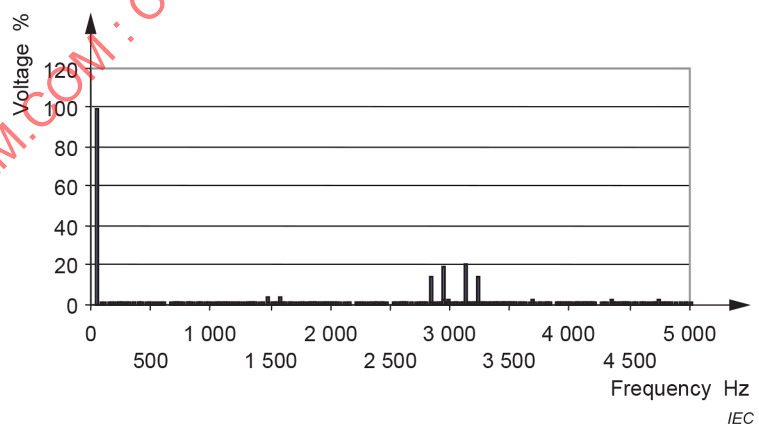

Figure B.2 – Frequency spectrum of the voltages at the terminals of a type A voltage-source converter (characterized by pronounced spikes close to the switching frequency and its multiples) f_1 = 50 Hz, f_s = 3 kHz

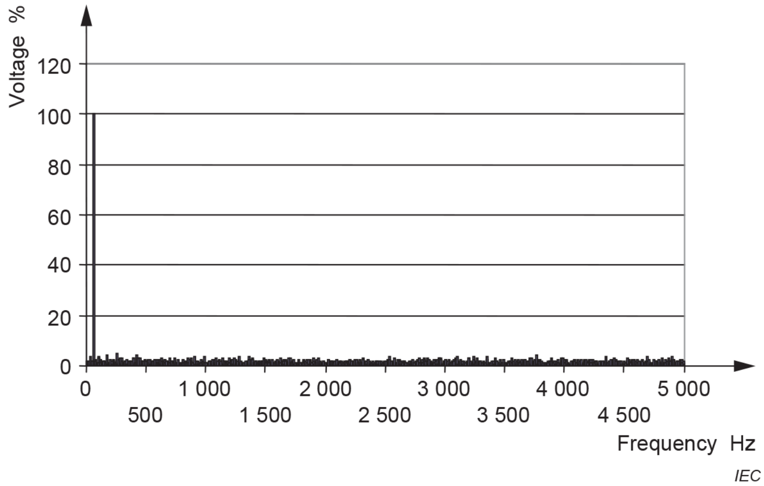

Figure B.3 – Frequency spectrum of the voltages of a type B voltage-source converter (characterized by a broad voltage spectrum without pronounced spikes) f_1 = 50 Hz, f_s average = 4,5 kHz

Specific considerations are necessary when the spectrum deviates significantly from a typical spectrum.

b) Typical values, historically based, for resonance frequencies of the motor for the modes of vibration caused by the harmonics

The relevant resonance frequencies of motors can be grouped according to Table B.1.

Table B.1 – Resonance frequencies of vibration mode r

Shaft height *H*	**Resonance frequencies of vibration mode r**			
	r = 0	r = 2	r = 4	r = 6
$H \leq$ 200 mm	> 4 000 Hz	> 600 Hz	> 4 000 Hz	> 5 000 Hz
$H \geq$ 280 mm	< 3 000 Hz	< 500 Hz	< 2 500 Hz	< 4 000 Hz

A magnetically excited tone is generated by the interaction of the fundamental fields of the number of pole pairs p of the fundamental frequency f_1 at the motor terminals and of one of the harmonic frequencies $n \times f_1$, as shown in the relevant frequency spectrum. The tones are of:

frequencies
$$f_r = f_1 \times (n \pm 1) = \begin{cases} (n+1) \times f_1 \\ (n-1) \times f_1 \end{cases}$$

vibration modes
$$r = p \pm p = \begin{cases} 2p \\ 0 \end{cases}$$

Usually combinations with $n \times f_1$, close to the switching frequency generate objectionable tones.

A reasonable increase of the audible noise is to be expected, if the frequency and the vibration mode of a tone are close to the corresponding values of the resonant structure of the motor. In some cases, objectionable tones may be avoided by changes to the parameter assignment of the converter.

Table B.2 shows the typical increase of noise, at converter supply, when compared to the noise at sinusoidal supply, with the same fundamental values of voltage and frequency.

Table B.2 – Increments of A-weighted noise values

Kind of converter	Case	Expected increment
Block-type current-source converter	6-pulse or 12-pulse	1 dB to 5 dB The higher values relate to motors with low ventilation noise. Increment depends on load.
Type A voltage-source converter	High frequency voltages of high amplitudes excite resonances of the motor	Up to 15 dB Increment does not depend on load. Initial calculation possible by adequate software.
	High frequency voltages of high amplitudes do not excite resonances of the motor	1 dB to 5 dB Increment does not depend on load.
Type B voltage-source converter	Broad voltage spectrum without pronounced spikes	5 dB to 10 dB Increment does not depend on load.

Bibliography

IEC TS 60034-25, *Rotating electrical machines – Part 25: AC electrical machines used in power drive system – Application guide*

ISO 1680, *Acoustics – Test code for the measurement of airborne noise emitted by rotating electrical machines*

ISO 80000-8, *Quantities and units – Part 8: Acoustics*

NEMA MG 1, *Motors and Generators – Part 9: Rotating Electrical Machines – Sound Power Limits and Measurement Procedures*

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SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

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MACHINES ÉLECTRIQUES TOURNANTES –

Partie 9: Limites de bruit

AVANT-PROPOS

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L’IEC 60034-9 a été établie par le comité d'études 2 de l’IEC: Machines tournantes. Il s’agit d’une Norme internationale.

Cette cinquième édition annule et remplace la quatrième édition, parue en 2003 et son amendement 1, paru en 2007. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l’édition précédente:

a) Le Tableau 2 et le Tableau 3 couvrent désormais les méthodes de refroidissement IC01, IC11, IC21 et IC31, IC71, IC81.
b) La présente édition ajoute le Tableau 3 pour les machines de 60 Hz, tandis que le Tableau 2, qui ne couvre que les machines de 50 Hz, ne présente pas de modification de niveaux.

c) Dans le Tableau 3, l'ajout du degré A vise à harmoniser les niveaux les plus élevés définis par l'IEC et NEMA, tandis que l'ajout du degré B visait à harmoniser les niveaux plus faibles mais plus restrictifs également définis par l'IEC et NEMA.

d) L'article "Détermination de l'augmentation de bruit provoquée par l'alimentation du convertisseur" a été transféré dans l'Annexe B et renommé "Informations sur l'augmentation type de bruit provoquée par l'alimentation du convertisseur".

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
2/2064/FDIS	2/2069/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à son approbation.

La langue employée pour l'élaboration de cette Norme internationale est l'anglais.

Une liste de toutes les parties de la série IEC 60034, publiées sous le titre général *Machines électriques tournantes*, peut être consultée sur le site web de l'IEC.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2, il a été développé selon les Directives ISO/IEC, Partie 1 et les Directives ISO/IEC, Supplément IEC, disponibles sous www.iec.ch/members_experts/refdocs. Les principaux types de documents développés par l'IEC sont décrits plus en détail sous www.iec.ch/standardsdev/publications.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous http://webstore.iec.ch dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
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- amendé.

INTRODUCTION

Les grandeurs acoustiques peuvent être exprimées en valeurs de pression acoustique ou en valeurs de puissance acoustique. L'utilisation d'un niveau de puissance acoustique, qui peut être spécifié indépendamment de la surface de mesure et des conditions d'environnement, évite les complications liées aux niveaux de pression acoustique, qui exigent de spécifier des données supplémentaires. Les niveaux de puissance acoustique donnent une mesure de l'énergie rayonnée et présentent des avantages sur le plan de l'analyse acoustique et de la conception.

MACHINES ÉLECTRIQUES TOURNANTES –

Partie 9: Limites de bruit

1 Domaine d'application

La présente partie de l'IEC 60034:

– spécifie les méthodes d'essai pour la détermination du niveau de puissance acoustique des machines électriques tournantes;
– spécifie les niveaux maximaux de puissance acoustique pondérée A pour les essais de réception en usine des machines électriques tournantes alimentées par réseau conformes à l'IEC 60034-1, dont les modes de refroidissement sont conformes à l'IEC 60034-6 et les degrés de protection conformes à l'IEC 60034-5, et qui présentent les caractéristiques suivantes:
  - conception normalisée, courant alternatif ou courant continu, sans modifications spéciales électriques, mécaniques ou acoustiques destinées à réduire le niveau de puissance acoustique
  - puissance assignée de 1 kW (ou kVA) jusqu'à 5 500 kW inclus (ou kVA)
  - vitesse assignée inférieure ou égale à 3 750 min^{-1}

Les limites de bruit applicables aux moteurs à courant alternatif alimentés par convertisseurs sont exclues. Voir l'Annexe B pour des recommandations relatives à ces conditions.

L'objet du présent document est d'établir les niveaux maximaux de puissance acoustique pondérée A, L_{WA} en décibels (dB), pour le bruit aérien émis par les machines électriques tournantes de conception normalisée, en fonction de la puissance, de la vitesse et de la charge, ainsi que de spécifier la méthode de mesure et les conditions d'essai appropriées pour la détermination du niveau de puissance acoustique des machines afin de fournir une évaluation normalisée du bruit des machines jusqu'aux niveaux maximaux spécifiés de puissance acoustique. Le présent document ne donne pas de correction relative à l'existence de caractéristiques tonales.

Les niveaux de pression acoustique à distance d'une machine peuvent être exigés dans certaines applications, telles que des programmes de protection de l'ouïe. Des informations sur une telle procédure dans un environnement d'essai normalisé sont fournies dans l'Article 7.

NOTE 1 Le présent document reconnaît que, pour des raisons économiques, des machines à niveau de bruit normalisé sont utilisées dans des zones non critiques ou avec des moyens supplémentaires d'atténuation du bruit.

NOTE 2 Lorsque des niveaux de puissance acoustique inférieurs à ceux spécifiés dans le Tableau 1, le Tableau 2 ou le Tableau 3 sont exigés, ils font l'objet d'un accord entre l'acheteur et le constructeur, car une conception électrique, mécanique ou acoustique spéciale peut entraîner des mesures supplémentaires.

2 Références normatives

Les documents suivants sont cités dans le texte de sorte qu'ils constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60034-1, *Machines électriques tournantes – Partie 1: Caractéristiques assignées et caractéristiques de fonctionnement*

IEC 60034-5, *Machines électriques tournantes – Partie 5: Degrés de protection procurés par la conception intégrale de machines électriques tournantes (Code IP) – Classification*

IEC 60034-6, *Machines électriques tournantes – Partie 6: Modes de refroidissement (Code IC)*

ISO 3741, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique - Méthodes de laboratoire en salles d'essais réverbérantes*

ISO 3743-1, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique - Méthodes d'expertise en champ réverbéré applicables aux petites sources transportables – Partie 1: Méthode par comparaison en salle d'essai à parois dures*

ISO 3743-2, *Acoustique – Détermination des niveaux de puissance acoustique émis par les sources de bruit à partir de la pression acoustique – Méthodes d'expertise en champ réverbéré applicables aux petites sources transportables – Partie 2: Méthodes en salle d'essai réverbérante spéciale*

ISO 3744, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique - Méthodes d'expertise pour des conditions approchant celles du champ libre sur plan réfléchissant*

ISO 3745, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique - Méthodes de laboratoire pour les salles anéchoïques et les salles semi-anéchoïques*

ISO 3746, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique – Méthode de contrôle employant une surface de mesure enveloppante au-dessus d'un plan réfléchissant*

ISO 3747, *Acoustique – Détermination des niveaux de puissance acoustique et des niveaux d'énergie acoustique émis par les sources de bruit à partir de la pression acoustique – Méthode d'expertise et de contrôle pour une utilisation in situ en environnement réverbérant*

ISO 4871, *Acoustique – Déclaration et vérification des valeurs d'émission sonore des machines et équipements*

ISO 9614-1, *Acoustique – Détermination par intensimétrie des niveaux de puissance acoustique émis par les sources de bruit – Partie 1: Mesurages par points*

ISO 9614-2, *Acoustique – Détermination par intensimétrie des niveaux de puissance acoustique émis par les sources de bruit – Partie 2: Mesurage par balayage*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse http://www.electropedia.org/
- ISO Online browsing platform: disponible à l'adresse http://www.iso.org/obp

3.1
niveau de puissance acoustique
L_W
dix fois le logarithme en base 10 du rapport de la puissance acoustique rayonnée par la source à l'essai et de la puissance acoustique de référence [W_o = 1 pW (10^{-12} W)] exprimé en décibels

3.2
niveau de pression acoustique
L_p
dix fois le logarithme en base 10 du rapport de la pression acoustique au carré et de la pression acoustique de référence au carré [P_o = 20 µPa (2 × 10^{-5} Pa)] exprimé en décibels

3.3
indice de surface de mesure
L_S
dix fois le logarithme en base 10 du rapport de la surface de mesure S et de la surface de référence [S_0 = 1 m^2] exprimé en décibels

3.4
valeur maximale
valeur qui définit la limite supérieure sans tolérance supplémentaire

4 Méthodes de mesure

4.1 Les mesures de niveaux de pression acoustique et le calcul du niveau de puissance acoustique produit par la machine doivent être effectués conformément à l'ISO 3744, à moins que l'une des méthodes alternatives spécifiées en 4.3 ou 4.4 ci-dessous ne s'applique.

NOTE La pratique générale consiste à utiliser la méthode parallélépipédique pour toutes les hauteurs d'axe.

4.2 Les niveaux maximaux de puissance acoustique spécifiés dans le Tableau 1, le Tableau 2 et le Tableau 3 ou ajustés selon le Tableau 4 sont relatifs aux mesures effectuées selon 4.1.

4.3 Le cas échéant, l'une des méthodes de précision ou de niveau d'exigence technique, comme les méthodes de l'ISO 3741, l'ISO 3743-1, l'ISO 3743-2, l'ISO 3745, l'ISO 9614-1 ou l'ISO 9614-2, peut être utilisée pour déterminer les niveaux de puissance acoustique.

4.4 La méthode plus simple, mais moins exacte spécifiée dans l'ISO 3746 ou l'ISO 3747 peut être utilisée, spécialement lorsque les conditions d'environnement exigées par l'ISO 3744 ne peuvent pas être satisfaites (par exemple, pour les grandes machines).

Toutefois, pour démontrer la conformité au présent document, les niveaux du Tableau 1, du Tableau 2 et du Tableau 3 doivent être diminués de 2 dB, à moins que, conformément à l'ISO 3746 ou l'ISO 3747, une correction due à l'inexactitude de mesure n'ait déjà été appliquée aux valeurs déterminées par cette méthode.

4.5 Dans le cas d'un essai effectué dans des conditions de charge assignée, les méthodes de l'ISO 9614 sont préférentielles. Toutefois, d'autres méthodes sont permises lorsque la machine en charge et les équipements auxiliaires sont isolés acoustiquement ou placés en dehors de l'environnement d'essai.