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Acceptance code for gears —

Part 1:
Determination of airborne sound power levels emitted by gear units

Code de réception des engrenages —
Partie 1: Détermination du niveau de puissance acoustique émis dans l'air par les transmissions par engrenages

Reference number
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Contents

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Foreword

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

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

International Standard ISO 8579-1 was prepared jointly by Technical Committees ISO/TC 60, *Gears* and ISO/TC 43, *Acoustics*.

ISO 8579 consists of the following parts, under the general title *Acceptance code for gears*:

— *Part 1: Determination of airborne sound power levels emitted by gear units*

— *Part 2: Determination of mechanical vibrations of gear units during acceptance testing*

Annexes A, B and C form an integral part of this part of ISO 8579. Annex D is for information only.

Introduction

The gear unit is only part of the total acoustic system which includes, in addition to the gear unit, the prime mover, driven equipment, gear unit mounting, foundation and acoustic environment. Each of these might affect the measured level of sound emitted from the gear unit. Therefore, unless otherwise agreed, the gear manufacturer is to ensure that the level of noise emitted from a gear unit under the test conditions in his factory is within contractually specified or negotiated limits.

The measurement method specified in this part of ISO 8579 determines the A-weighted sound power level of sound radiated over a reflective surface (for example, in an anechoic room with a reflective floor). Correction values are provided so that the procedure can be applied, within specified limits, in factory test areas, commonly used by a manufacturer.

In some instances it may be necessary to determine sound power levels in octave or one-third-octave bands; procedures are included for that purpose. However, the use of those procedures is to be agreed between the manufacturer and purchaser.

Acceptance code for gears —

Part 1:
Determination of airborne sound power levels emitted by gear units

1 Scope

This part of ISO 8579 specifies the conditions under which sound emitted from gear units is determined in order to establish a common procedure for comparison.

It is applicable to all power transmission gearing other than gears for fine mechanisms.

The methods in this part of ISO 8579 are based on ISO 3744 and ISO 3746.

NOTE 1 This part of ISO 8579 does not include a method using substitution of a reference sound source in a reverberation room for determining sound power level. To make use of this method, see ISO 3743.

If it is necessary to determine sound power levels in octave or one-third-octave bands, the procedures of this part of ISO 8579 should be agreed upon between manufacturer and purchaser.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 8579. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 8579 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 3744:1981, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for free-field conditions over a reflecting plane.*

IEC 225:1966, *Octave, half-octave and third-octave band filters intended for the analysis of sounds and vibrations.*

IEC 651:1979, *Sound level meters.*

3 Definitions

For the purposes of this part of ISO 8579, the following definitions apply.

3.1 background noise: Any sound at the points of measurement which does not originate from or is not directly emitted by the gear unit.

3.2 band pressure level: The effective sound pressure level corresponding to the sound energy contained within the band.

3.3 measurement surface: An imaginary surface enveloping the gear unit, on which the measurement points lie. (See 5.4.1.)

3.4 measurement-surface area, S: The area, expressed in square metres, of the measurement surface.

3.5 measurement-surface quantity, L_S: The sound pressure level which relates different measurement-surface areas:

$$L_S = 10 \log_{10}\left(\frac{S}{S_o}\right) \text{ dB}$$

where

$S_o = 1 \text{ m}^2$

3.6 nearfield: Zone, the limit of which is defined by the distance r_n from the geometric centre of the sound source beyond which the sound pressure decreases in proportion to $1/r$.

Beyond this zone, if the distance is doubled, the reduction of the sound pressure level should be 6 dB with a permissible deviation of 1 dB. The nearfield limit depends upon the frequencies of interest.

3.7 frequency spectrum of the noise: Spectrum showing the sound pressure level distribution throughout the frequency range. The appearance of the spectrum depends on the bandwidth characteristics of the analyser used.

3.8 sound pressure level, L_p: Level defined by

$$L_p = 20 \log_{10}\left(\frac{p}{p_o}\right) \text{ dB}$$

where

p is the measured root-mean-square sound pressure;

p_o is the reference sound pressure, expressed in the same units as p [for air $p_o = 20$ µPa[1]].

3.9 A-weighted sound pressure level, L_{pA}: Sound pressure level reading given by a sound level meter complying with IEC 651, with frequency weighting A.

NOTE 2 This is often abbreviated to "weighted sound level" or "sound level" in English-speaking countries.

3.10 sound power level, L_W: Level defined by

$$L_W = 10 \log_{10}\left(\frac{P}{P_o}\right) \text{ dB}$$

where

P is the measured sound power;

P_o is the reference sound power, expressed in the same units as P [= 1 pW[2]].

1) 1 µPa = 10^{-6} N/m^2

2) 1 pW = 10^{-12} W

NOTE 3 L_{WA} is an A-weighted sound power level, determined in such a manner that the acoustic power level in each of the bands is obtained with frequency weighting A.

4 Instrumentation

4.1 Sound level meter

The sound level meter shall comply with the requirements of IEC 651 for a type 1 instrument.

The instructions on the use of the equipment shall be followed to ensure that the intended degree of precision is met.

Any filter used for noise analyses shall comply with IEC 225. Narrow-band or Fourier Transform equipment may also be used.

NOTE 4 Octave or one-third-octave band levels determined by recombining narrow-band or discrete-frequency levels may not be accurate.

4.2 Calibration of measuring equipment

The overall acoustical performance of the measuring equipment shall be checked and any specified adjustments made immediately before and rechecked immediately after each series of machine noise measurements.

More detailed calibrations of all the measuring equipment shall be carried out at least once every two years (see ISO 3744:1981, 5.5).

4.3 Location of instruments and observer

Any measuring amplifiers, filters, or observers shall be positioned to minimize errors due to reflections.

5 Test conditions

5.1 Objectives of the test

In principle, only that noise emitted from the gear unit should be measured. However, equipment that is integral with and near and essential to the function of the gear unit in service (for example pumps, fans, etc.) shall be included. The type of additional equipment used and the condition under which it was operated shall be exactly stated in the test report.

If a gear unit is mounted in a set of machinery in such a way that the individual level of noise emitted by the gear unit cannot be measured, and if the level of noise emitted from the set is not of interest, measurement in accordance with other agreed procedures should be used (such as acoustic intensity, cross-correlation, or structural vibration measurements).

5.2 Test conditions of the gear unit

For the purposes of this part of ISO 8579, the conditions given in 5.2.1 to 5.2.5 shall apply, unless otherwise agreed between the gear manufacturer and the purchaser.

5.2.1 The unit shall be tested at its intended operating speed or, if intended for variable speed service, at the arithmetic mean of its speed range.

5.2.2 The gear unit shall be tested in its intended direction of rotation or, if reversible, in both directions.

5.2.3 The gear unit may be operated with or without load, at the gear manufacturer's discretion.

5.2.4 The test measurements shall be conducted using the operating lubricating system and the lubricant viscosity equivalent to the operating viscosity.

5.2.5 Noise measurement shall be conducted when the machinery is operating within its design temperature range.

5.3 Installation and coupling of the gear unit

The test set-up and coupling arrangements can have a significant influence on the sound radiation from gear units.

The gear units should be installed in such a way that the influence of the test environment, including the driving machine, loading device, and foundation, will be minimized to the greatest practicable extent. Some of the measures which can help to achieve this objective are given in 6.3. Noises radiated from driving machines, loading devices or foundations shall be regarded as background noises. If necessary, background noises shall be determined in accordance with 6.3.

Details of test set-up and operating conditions shall be carefully stated in the test report.

5.4 Measurement surfaces, distances, and position and number of measurement points

5.4.1 Measurement surfaces

A reference surface in the shape of a parallelepiped shall be set out as a hypothetical boundary around the gear unit. In laying out this boundary, individual projecting construction features which do not make a significant contribution to sound radiation may be neglected. The measurement surface lies at a distance d from the enclosing reference parallelepiped (see figures 1 to 8) and ends at a sound-reflecting boundary surface of the installation site (for example, at the floor or walls).

The distance from the measurement surface to all other surfaces, such as walls of the room or other machine panels, shall be at least twice the distance from the measurement surface to the surface of the reference parallelepiped. If any part of the measurement surface does not meet this condition, that part is disregarded and the remaining measurement surface may be extended to the corresponding wall or panel, provided it is reflective (see figure 3).

5.4.2 Measurement distance

In general, the measurement distance d is equal to 1 m. A distance of less than 1 m may be chosen, but there is a danger of entering the nearfield zone where determination of sound power is not allowed from simple measurements. Measurement from a very short distance (min. 0,25 m) allows comparison only between gear units of the same type which have been measured in the same way.

Measurement distances other than 1 m shall be stated in the test report.

5.4.3 Position and number of measurement points

The measurement points may be arranged in one of the ways given in 5.4.3.1 to 5.4.3.3.

5.4.3.1 Complete measurement-point arrangement

The measurement points shall be chosen with regard to the size of the reference parallelepiped and the arrangements shown in figures 2, 4, 6 and 8. The number of measurement points shall be increased if the horizontal distance between adjacent points exceeds 2 m or if the difference, in decibels, between the highest and lowest values of sound pressure level is greater than the number of measurement points. Care shall be taken that the measurement points are evenly spaced. The measurement points shall be so arranged that the microphone is not placed in air currents from exhaust openings or rotating parts.

Figure 6 shows the measurement-point arrangement for the special case of a gear unit installed in a pit.

5.4.3.2 Simplified measurement-point arrangement

The basic arrangements of measurement points shown in figures 2, 4, 6 and 8, or even more simple arrangements, may be sufficient, if it has been established by test measurements of the gear unit type that the sound field is sufficiently even to the extent that the sound level determined from the measured values will be equal to or higher than that which would be determined by a full complement of measured values.

5.4.3.3 Single-point measurement for acceptance testing

Because of the cost of sound power testing, a standard production test for a gear unit may be conducted using a single-point sound pressure measurement. This single-point measurement may only be used when taking account that:

— a single point cannot be used to obtain a true sound power level;

— the test area and unit type must be qualified by prior sound power determination in accordance with 5.4.3.1;

— the point of sound pressure measurement should be selected as the surface measuring point of least perturbation established by the sound power determination.

The single-point sound pressure method shall only be used when agreed between manufacturer and purchaser.

5.5 Test room

Gear unit sound may be measured in accordance with this part of ISO 8579 if the influence of room acoustic reaction (reverberation) on the sound field near the measurement points is not more than 3 dB. This requirement is met if the environmental correction K_2 is less than or equal to 3 dB (see 7.1.4) or 3 dB for each octave (one-third-octave, see 8.1.4). K_2 less than or equal to 3 dB is acceptable for gear unit measurements. It is an intermediate value between those of ISO 3744 and ISO 3746.

When the distance from the measurement surface to the nearest flat surface, including room walls and other machines, is at least twice the measurement distance, it may be assumed that the test room is suitable if the interior volume of the room is nearly numerically equal to, or greater than, the area of the measurement surface in square metres multiplied by 100. If the test room does not meet these volumetric requirements, room suitability may be determined as follows.

Place a small broad-band noise source at the position to be occupied by the geometric centre of the gear unit under test. Using this noise source, determine the average sound pressure levels at two sets of measurement points. These two sets of measurement points are:

a) the preselected measurement points;

b) the corresponding points half or twice the distance from the source (provided that the points are not in the nearfield).

The room is suitable if the difference between the two means is at least 5 dB.

Measurements are then correct in accordance with 7.1.4 or 8.1.4.

If the environmental factor, K_2, exceeds 3 dB, then measurements cannot be corrected in accordance with 7.1.4 because incremental pressures included in the measured levels are excessive. In such cases, recalibration with smaller measurement distances may be tried, free-hanging absorbers or additional sound absorption material may be installed, or a more suitable room chosen.

6 Procedure for obtaining sound pressure level data

Before carrying out measurements, review the conditions set out in clause 5 to establish such corrections as are necessary.

Note that the measurements may be distorted under difficult conditions (for example by vibrations, electrical and magnetic fields, wind or gas streams, abnormal temperature).

6.1 Obtaining A-weighted sound pressure levels

At each measurement point, observe the sound level, L_{pAS}, on the sound level meter using the frequency-weighting characteristic A and the time-weighting characteristic S. From the observed levels, record the time-averaged level, L_{pASm}. The measurement time for this mean level should be chosen such that the sound level recorded is representative of normal operating conditions.

6.2 Obtaining sound pressure level spectra

Sound pressure level spectra should in general be made without weighting in frequency bands. Measurements at each measurement point, in each octave band frequency range, will be sufficient and are recommended unless pure tones are present, in which case third-octave, narrow-band spectra or Fourier Transform analysis may be necessary.

6.3 Background noise

With only the gear unit and essential auxiliaries (see 5.1) at a standstill, measure background noise levels at each measurement point and record them as described in 6.1 and 6.2. These levels should preferably be low enough not to influence measurements of gear noise. This is assured if A-weighted background noise levels are lower than levels observed during the tests by 10 dB or more in each band. If this is not the case, the measures specified in 6.3.1 to 6.3.4 might help to reduce background noise.

6.3.1 Move as many of the background noise sources as possible out of the test area, or as far away as safety (because of extended shafts) and the area will allow.

6.3.2 Background noise sources can, if practicable, be acoustically screened. Possible reflection of gear noise from screens shall be considered.

6.3.3 Subject to agreement, operating conditions might be altered to avoid, for example, structural resonances in the test area.

6.3.4 If the above measures do not sufficiently reduce background noise, a correction shall be made in accordance with 7.1.2 when background levels are between 3 dB and 9 dB below the levels observed in accordance with 6.1 and 6.2.

6.4 Calculation of S and L_S

The measurement-surface area, S, in square metres, is given by

$S = 4(ab + ac + bc)$ (see figure 2)

$S = 2(2ab + ac + bc)$ (see figure 4)

$S = 4ab$ (see figure 6)

$S = 4(2ab + ac + bc)$ (see figure 8)

The measurement-surface quantity L_S is given by

$$L_S = 10 \log_{10}\left(\frac{S}{S_o}\right) \text{ dB}$$

where S_o is the reference surface area $(= 1 \text{ m}^2)$.

Table 1 gives values of L_S for various values of S.

Only an approximate value of the measurement-surface area need be determined since an error of − 20 % to + 25 % will only result in a measurement-surface value change of 1 dB.

Table 1 — Measurement-surface quantity, L_S (relative to the measurement-surface area; $S_o = 1 \text{ m}^2$)

Measurement-surface area S m²	Measurement-surface quantity L_S dB
0,63	− 2
0,8	− 1
1	0
1,25	+ 1
1,6	+ 2
2	+ 3
2,5	+ 4
3,2	+ 5
4	+ 6
5	+ 7
6,3	+ 8
8	+ 9
10	+ 10
12,5	+ 11
16	+ 12
20	+ 13
25	+ 14
32	+ 15
40	+ 16
50	+ 17
63	+ 18
80	+ 19
100	+ 20
125	+ 21
160	+ 22
200	+ 23
250	+ 24
320	+ 25
400	+ 26
500	+ 27
630	+ 28

7 Determination of A-weighted sound power level

7.1 Determination of the mean surface sound pressure level, $\overline{L_{pAm}}$

The mean surface sound pressure level, $\overline{L_{pAm}}$, shall be determined in accordance with 7.1.1 to 7.1.3 from values of sound pressure measured at the measurement surface.

7.1.1 Time-averaged values

Values obtained in accordance with 6.1 and 6.2 are time-averaged values.

7.1.2 Corrections for background noise

If background noise is to be taken into account, correction values K_1 at each measurement point i, which depend on the difference, in decibels, between measurements in accordance with 6.1 and 6.2 and background noise measurements, shall be taken from table 2.

If the difference is less than 3 dB at any point, the sound pressure level so corrected is not accurate.

Table 2 — Correction values, K_1, for background noise

Difference between the values obtained in accordance with 6.1 and 6.3 dB	Correction values, K_1, to be subtracted from values obtained in accordance with 6.1 dB
3	3
4 to 5	2
6 to 9	1

7.1.3 Mean surface sound pressure level, $\overline{L_{pAm}}$

The mean surface sound pressure level, $\overline{L_{pAm}}$, shall be calculated from all the time-averaged values determined at all measurement points, and corrected if necessary in accordance with 7.1.2. If the difference between the highest and lowest values does not exceed 6 dB, the arithmetic mean may be used:

$$\overline{L_{pAm}} = \frac{1}{n} \sum_{i=1}^{n} (L_{pASmi} - K_{1i})$$

where

K_{1i} is the K_1 correction at each point if necessary;

L_{pASmi} is the time-averaged sound level at measurement point i (see 6.1).

If the difference exceeds 6 dB(A), the mean of each individual sound pressure level shall be determined on the energy basis. $\overline{L_{pAm}}$ is then given by

$$\overline{L_{pAm}} = 10 \log_{10} \frac{1}{n} \sum_{i=1}^{n} 10^{(L_{pASmi} - K_{1i})/10} \text{ dB}$$

7.1.4 Determination of the environmental correction factor, K_2

The effect of the acoustic reaction of the test area on the surface sound pressure levels determined in accordance with 7.1.3 is mainly dependent on the absorption characteristics of the test room and on the quotient of its volume, V, to the measurement surface, S.

The acoustic reaction (0 dB to 3 dB) can be dealt with by subtracting an integer number correction factor, K_2, from the mean surface sound pressure level. The correction factor can be determined directly using a reference sound source (see annex C) or table 3.

Table 3 — Environmental correction factor, K_2

Room furnishings and fittings	K_2, for usual machine and testing room, dependent on the measurement surface dB — Quotient room volume by measurement surface area[1)] V/S: 25	32	40	50	63	80	100	125	160	200	250	320	400	500	630	800	1 000
A: Room with strongly reflecting walls (e.g. tiles, flat concrete or plaster)	—						$K_2 = 3$		$K_2 = 2$			$K_2 = 1$				$K_2 = 0$	
B: Room without features given under A or C.	—				$K_2 = 3$		$K_2 = 2$			$K_2 = 1$				$K_2 = 0$			
C: Room with weakly reflecting surface with some sound-absorbing areas	—		$K_2 = 3$		$K_2 = 2$			$K_2 = 1$				$K_2 = 0$					

NOTE — This table helps estimate K_2 without frequent recourse to sound-source measurements (see 5.5 and annex C). The qualification test by direct measurement is, however, essential in cases where application of this table raises doubts or gives correction values greater than 3 dB (zones indicated with a dash).

1) The measurement-surface area, S (m^2), room characteristics and volume, V (m^3), are known.

7.1.5 Calculation of the corrected mean sound pressure level, $\overline{L_{pAf}}$

If necessary, the correction factor K_2 shall be used to calculate the corrected mean sound pressure level, $\overline{L_{pAf}}$:

$$\overline{L_{pAf}} = \overline{L_{pAm}} - K_2$$

7.2 Calculation of the A-weighted sound power level, L_{WA}

The A-weighted sound power level is usually approximated as the sum of the corrected mean pressure level $\overline{L_{pAf}}$ and the measurement-surface quantity L_S in accordance with 6.4:

$$L_{WA} = \overline{L_{pAf}} + L_S$$

7.3 Measurement uncertainty

Because of the characteristic tolerances of instruments, disturbances during measurement and uncertainties inherent in the above correction procedures, the measurement uncertainty for the sound power determination is $\pm$ 2 dB.

NOTE 5 If the distribution is normal and the standard deviation, s, is equal to 1 dB, then in 70 % of all cases uncertainties will be less than $\pm$ 1 dB, and in 95 % of all cases uncertainties will be less than $\pm$ 2 dB.

8 Evaluation of octave and one-third-octave sound power

NOTE 6 Everything considered for "octave" may be applied to "one-third-octave".

8.1 Determination of the octave (and one-third-octave) band mean surface sound pressure level, $\overline{L_{oct}}$ $(\overline{L_{1/3\text{-}oct}})$

The mean surface sound pressure level, $\overline{L_{oct}}$ $(\overline{L_{1/3\text{-}oct}})$, shall be determined in each octave (one-third-octave) band (125 Hz to 8 kHz) from values of the octave (one-third-octave) band pressure level at each point of the measured surface.

8.1.1 Time-averaged values

See 7.1.1.

8.1.2 Correction for background noise in octave and one-third-octave bands

If background noise is to be taken into account, correction values, $K_{1,\text{oct},i}$, for each octave (one-third-octave) band and at each point, which depend on the difference, in decibels, in each octave (one-third-octave) band, shall be taken from table 2.

If the difference is less than 3 dB at any point in an octave (one-third-octave) band, the sound pressure level in that octave (one-third-octave) band is not accurate.

8.1.3 Mean surface sound pressure level for octave (one-third-octave) evaluation

The mean surface sound pressure level, $\overline{L_{oct}}$ $(\overline{L_{1/3\text{-}oct}})$, for each octave (one-third-octave) band shall be calculated from all the time-averaged values determined at all measurement points and corrected separately for background noise.

If the difference between the highest and lowest values does not exceed 6 dB in any octave (one-third-octave) band, the arithmetic mean may be used.

If this difference exceeds 6 dB, the mean of the individual sound pressure levels for the band considered is to be determined on the energy basis (see 7.1.3).

8.1.4 Determination of the environmental correction factor, $K_{2,\text{oct}}$

The factor for each octave (one-third-octave) band shall be determined by using a reference sound source (see annex C) or method A in table 3 ($K_{2,\text{oct}} = K_2$).

8.1.5 Calculation of corrected mean octave (one-third-octave) band pressure levels, $\overline{L_{oct,c}}$

Factors determined in accordance with 8.1.4 shall be used to calculate the corrected mean octave (and one-third-octave) band pressure:

$$\overline{L_{oct,c}} = \overline{L_{oct}} - K_{2,\text{oct}}$$

8.2 Calculation of octave and one-third-octave band power levels, $L_{W,\text{oct}}$

The octave (one-third-octave) band power level, $L_{W,\text{oct}}$, is the sum of the corrected mean octave (one-third-octave) band pressure level, $\overline{L_{oct,c}}$, and the measurement-surface quantity, L_S:

$$L_{W,\text{oct}} = \overline{L_{oct,c}} + L_S$$

8.3 Octave and one-third-octave power level measurement uncertainty

Band levels determined in accordance with this part of ISO 8579 shall lie within the confidence limits determined by the standard deviations given in table 4.