

INTERNATIONAL STANDARD

ISO
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Acceptance code for gear units —

Part 1:

Test code for airborne sound

Code de réception des engrenages sous carter —

Partie 1: Code d'essai pour la détermination du bruit aérien



Reference number
ISO 8579-1:2002(E)

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Contents

Page

Foreword.....	iv
Introduction	v
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Gear configuration and acoustic environment.....	2
5 Sound power level determination	3
6 Determination of emission sound pressure level	16
7 Installation and mounting conditions.....	17
8 Operating conditions during sound measurements	18
9 Information to be recorded	19
10 Information to be reported	19
11 Declaration and verification of sound emission values	19
Annex A (informative) Examples of microphone positions on the measurement surface for different gear types and sizes.....	20
Annex B (informative) Typical sound levels for different gear types and sizes (sound power and sound pressure)	29
Annex C (informative) Information for the determination of airborne sound power levels using the methods of ISO 3744:1981 and ISO 3746:1979	44
Bibliography	53

Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

Attention is drawn to the possibility that some of the elements of this part of ISO 8579 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8579-1 was prepared by Technical Committee ISO/TC 60, *Gears*.

This second edition cancels and replaces the first edition (ISO 8579-1:1993), which has been technically revised.

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

- *Part 1: Test code for airborne sound*
- *Part 2: Determination of mechanical vibrations of gear units during acceptance testing*

Annexes A, B and C of this part of ISO 8579 are for information only.

Introduction

The sound emitted by a gear unit or gearmotor can be radiated by the casing of the gear unit, the driving system (e.g. motor, coupling, another gear unit), and the connected structures included in the gear-drive system.

On-site and on the shop test stand, the perceived sound can be significantly increased by reverberation effects or by the radiation of extraneous sources.

Depending on the type of gear unit or gearmotor, as well as on the requirement of the purchaser, it may be necessary for the manufacturer or supplier to know

- a) the sound emitted by the gear unit, excluding the sound from the driver/motor, driven system and transmission elements,
- b) the sound emitted by the gearmotor, including the motor and the transmission elements,
- c) the sound emitted by subsystems or auxiliaries, for example, the lubrication system, and
- d) the sound emitted by each of those elements in respect of a given requirement, or in view of an efficient sound-proofing of the installation.

This part of ISO 8579 describes methods for the determination of the sound emitted by a gear unit alone, a gearmotor or a gear-drive system. Sound emission is expressed in terms of the sound power level of the transmission system and the emission sound pressure level at the relevant work station (see 6.2).

Annex A provides examples of practical microphone positions on the measurement plane for different gear types and sizes. Annex B gives typical sound-pressure and sound power levels for different gear types and sizes. Annex C, developed for ISO 8579-1:1993, provides information on the determination of airborne sound power levels emitted by gear units, using a combination of the two methods given in clause 5.

Acceptance code for gear units —

Part 1:

Test code for airborne sound

1 Scope

This part of ISO 8579 specifies the instructions and standardized conditions necessary for the determination of the airborne sound emission of gear units and gearmotors. It also specifies the allowed measurement methods, together with the operating and mounting conditions used for the test.

The emission characteristics include emission sound pressure levels at specified positions and the sound power level. The determination of these quantities is necessary for

- a) manufacturers of gear units or gearmotors, in order that they may be able to declare the emitted sound,
- b) for comparing the sound emitted by gear units and gearmotors under service operation, and
- c) for the purpose of noise control at the design stage.

This part of ISO 8579 has the aim of ensuring, with its use, the reproducibility of the determination of the airborne sound emission characteristics within specified limits determined by the grade of accuracy of the basic measurement method used. The sound measurement methods allowed by this part of ISO 8579 are engineering methods (grade 2) and survey methods (grade 3).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 8579. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 8579 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3743-1:1994, *Acoustics — Determination of sound power levels of noise sources — Engineering methods for small, movable sources in reverberant fields — Part 1: Comparison method for hard-walled test rooms*

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

ISO 3745:—¹⁾, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Precision methods for anechoic and semi-anechoic rooms*

ISO 3746:1995, *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

1) To be published. (Revision of ISO 3745:1977)

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

ISO/TR 7849:1987, *Acoustics — Estimation of airborne noise emitted by machinery using vibration measurement*

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

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

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

3 Terms and definitions

For the purposes of this part of ISO 8579, the terms and definitions given in ISO 3743-1, ISO 3744, ISO 3745, ISO 3746, ISO 4871, ISO 9614-1, ISO 9614-2 and ISO 11203 apply.

4 Gear configuration and acoustic environment

4.1 Gear configuration

This part of ISO 8579 is concerned with industrial gear units and gearmotors with gearing of the cylindrical, bevel and worm types.

There are three gear configurations to be considered:

- a) gear unit, independent of driving or driven systems;
- b) gearmotor, with motor integral to the gear unit;
- c) gear-drive system, where the motor or driving equipment is installed on a common baseplate with other required auxiliary equipment.

The purchaser and manufacturer shall agree on whether sound is to be measured on the system or on the gear unit alone.

Safety guards, such as cardan and coupling guards, and insulation hoods, where applicable, shall be present during the sound emission determination.

4.2 Acoustic environments

This part of ISO 8579 allows for three possible acoustic environments for each configuration. In each case, the gear configuration may be installed

- on-site (see 7.2.4),
- on the shop test stand (see 7.2.3), or
- in a specific facility intended for acoustic measurements (see 7.2.2).

5 Sound power level determination

5.1 General

Unless otherwise specified, the determination shall be an A-weighted sound power, with the testing being conducted in the manufacturer's test facility using the method chosen by the manufacturer.

5.2 Methods

In determining the method to be used, the grade of accuracy of the measurement must be considered. Each ISO standard method gives specific uncertainty limits for the grades, with grade 2 being more precise than grade 3. A typical example, taken from ISO 9614-2:1996, is given in Table 1.

Table 1 — Uncertainty in the determination of sound power levels

Octave band centre frequencies	One-third octave band centre frequencies	Standard deviations	
		Engineering (grade 2) dB	Survey (grade 3) dB
Hz	Hz		
63 to 125	50 to 160	3	—
250	200 to 315	2	—
500 to 4 000	400 to 5 000	1,5	—
—	6 300	2,5	—
A-weighted ^a	—	1,5 ^b	4
NOTE The stated uncertainty of the A-weighted estimate does not apply if the total A-weighted power in the one-third-octave bands outside the range 400 Hz to 5 000 Hz exceeds the total within this range; individual uncertainties then apply.			
^a 63 Hz to 4 kHz or 50 Hz to 6,3 kHz.			
^b The true value of the A-weighted sound power level is expected with a certainty of 95 % to be in the range of ± 3 dB about the measured value.			

The preferred methods for determining the sound power level are the following grade 2 accuracy methods:

- ISO 3743-1;
- ISO 3744;
- ISO 9614-1 or ISO 9614-2.

If it has been shown that grade 2 cannot be attained, then one of the following grade 3 methods may be used:

- ISO 3746;
- ISO 9614-1 or ISO 9614-2.

If none of the above methods are practicable, the method of ISO/TR 7849 may be used.

For selection of a basic standard for the determination of the sound power level of an industrial gear unit or gearmotor, use Table 2 or Table 3.

The differences between Tables 2 and 3 reflect the relative ease of performing measurements for gear units as opposed to gearmotors. Table 2 addresses gear units and gear-drive systems, which are an assembly of components and thus present a more challenging measurement procedure. Table 3 represents the relatively more

easily achieved measurements for a “close-coupled” gearmotor configuration where the sound of the gear unit is not separated from the sound of the motor. The term “gearmotor” may also include other close-coupled arrangements where the sound cannot be separated. This would include close-coupled gears and generators and close-coupled hydraulic motors.

NOTE Comments on recommended International Standards

ISO 3743-1 is based upon a hard-walled room and low background noise. This International Standard gives specifications for sound pressure measurement in octave bands in order to enable the sound power level to be calculated.

ISO 3744 is based upon a non-reverberant environment and low background noise. This International Standard specifies a method for calculating the sound power level from the measured A-weighted sound pressure level or the sound pressure level in octave or one-third octave bands.

ISO 3745 is based upon a special anechoic or semi-anechoic test room. This International Standard gives specifications for A-weighted sound pressure level measurement in order to enable the sound power level to be calculated.

ISO 3746 is less demanding. It gives specifications for the A-weighted sound pressure level only and provides an A-weighted sound power level with grade 3 accuracy.

ISO 9614 can be used in all environments, including, to a large extent, reverberation and extraneous sound sources. It gives specifications to sound intensity and sound pressure measurements. Depending on the level of the reverberation and extraneous sound, it provides the sound power level either as an A-weighted, overall level or in octave bands. For grade 3 measurements only, the overall A-weighted sound power level is available.

ISO 9614-1 requires measurements of sound intensity and, simultaneously, of sound pressure (at discrete points). In this case, the number of points is generally higher than the number of points used for the standards based on sound pressure measurements.

ISO 9614-2 requires measurement of sound intensity and, simultaneously, of sound pressure by scanning. This could be made on a partial or global surface, depending on the configuration of the machine. The method generally reduces the measurement time.

ISO/TR 7849 is an ISO Technical Report which is used only when the other methods are impracticable. This method is based upon measurement of vibration velocity of the relevant parts of the gear unit or gearmotor. It provides an estimation of the A-weighted sound power level or sound power level in octave, or one-third octave, bands.

5.3 Reference box, measurement surface, microphone positions and intensity probe considerations

5.3.1 General

When either ISO 3744, ISO 3746, ISO 9614-1 or ISO 9614-2 is used, 5.3.2 to 5.3.4 are applicable.

5.3.2 Reference box

The reference box is a hypothetical surface, generally the smallest simple volume (parallelepiped or box) containing the gear unit or gearmotor to be measured, but excluding auxiliaries, transmission elements and the driver for the gear unit. The reference box for a gear-drive system would just include the structure supplied by the gear-drive manufacturer. The box encloses the source and terminates on the reflecting plane (hard ground or water). Examples of reference boxes are shown in Figures 1, 2 and 3.

NOTE Small components of the source, which do not contribute to the sound radiation, can lie outside the reference box.

Table 2 — Standard selection for sound power level determination of gear units and gear-drive systems

Acoustic environment	Grade of accuracy	Standard for sound power level determination		
		Gear unit or gear drive system input power level, kW		
		≥ 0,1 to ≤ 10	> 10 to ≤ 300	> 300
Specific facility a, b, c	2	ISO 3744 ^d ISO 3743-1 ^e ISO 9614	ISO 9614 ISO 3744 ^d	ISO 9614
Shop test stand ^a	2	ISO 9614 ^b		impracticable
	3	ISO 9614 ISO 3746 ^f		ISO 9614
On-site	2	ISO 9614 ^{f, b}		impracticable
	3	ISO 9614 ^f ISO 3746 ^{f, g}	ISO 9614 ^f ISO/TR 7849 ^h	
NOTE 1 The standard written in bold letters is the preferred standard, to be used wherever practicable.				
NOTE 2 For each measurement situation, the standard selection order of preference is indicated by the order of listing.				
NOTE 3 ISO 9614 refers to either ISO 9614-1 or ISO 9614-2.				
^a The power available for test may not be sufficient to represent on-site conditions.				
^b The size of the gear unit may prevent proper measurement.				
^c ISO 3745 could be used for grade 2 accuracy in a specific facility.				
^d Normally requires an anechoic environment above a reflective plane.				
^e Normally requires a reverberant room.				
^f The background noise may be too erratic for proper measurement.				
^g There may not be sufficient access between units for measurement.				
^h The time to make all the necessary measurements may be too extensive.				

Table 3 — Standard selection for sound power level determination of gearmotors

Acoustic environment	Grade of accuracy	Standard for sound power level determination	
		Gearmotor rated power level, kW	
		$\geq 0,1$ to ≤ 300	> 300
Specific facility ^{a, b, c}	2	ISO 3744 ^d ISO 9614	ISO 9614 ISO 3744 ^d
Shop test stand ^a	2	ISO 3744 ^d ISO 9614	ISO 9614 ^b
	3	ISO 3746 ^e	ISO 9614 ^b
On-site ^b	2	ISO 9614 ISO 3744 ^f	ISO 9614
	3	ISO 3746 ^f ISO 9614	ISO 9614 ISO 3746 ^f
NOTE 1 The standard written in bold letters is the preferred standard, to be used wherever practicable.			
NOTE 2 For each measurement situation, the standard selection order of preference is indicated by the order of listing.			
NOTE 3 ISO 9614 refers to either ISO 9614-1 or ISO 9614-2.			
^a The power available for test may not be sufficient to represent on-site conditions. ^b The size of the gear unit may prevent proper measurement. ^c ISO 3745 could be used for grade 2 accuracy in a specific facility. ^d Normally requires an anechoic environment above a reflective plane. ^e Normally requires a reverberant room. ^f The background noise may be too erratic for proper measurement.			

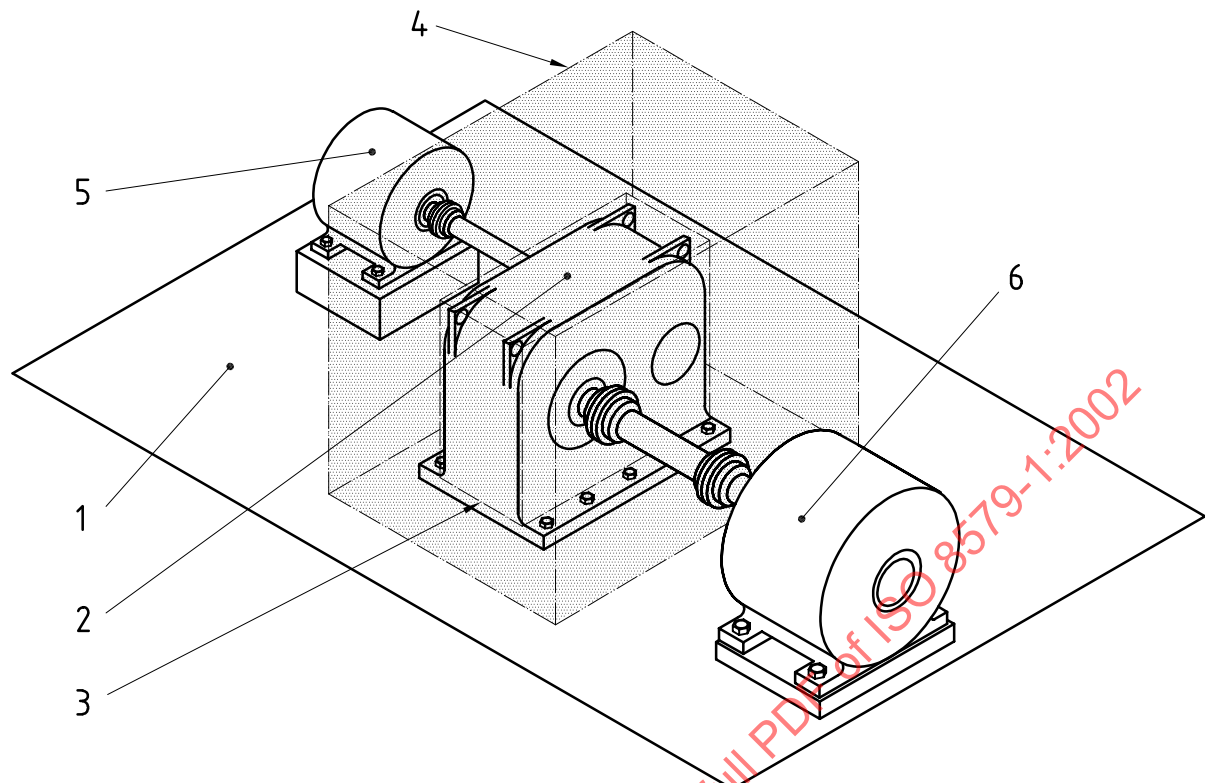
5.3.3 Measurement surface

The measurement surface is a surface generally enveloping the reference box at a given distance.

The distance between the measurement surface and the reference box is called the measurement distance. It depends on the basic method used:

- for ISO 3744, based on a sound pressure level measurement, the distance, d , shall be 1 m;
- for ISO 9614, based on a sound intensity measurement, the distance, d , shall be
 - for ISO 9614-1, $d \geq 0,5$ m, and
 - for ISO 9614-2, $d \geq 0,2$ m.

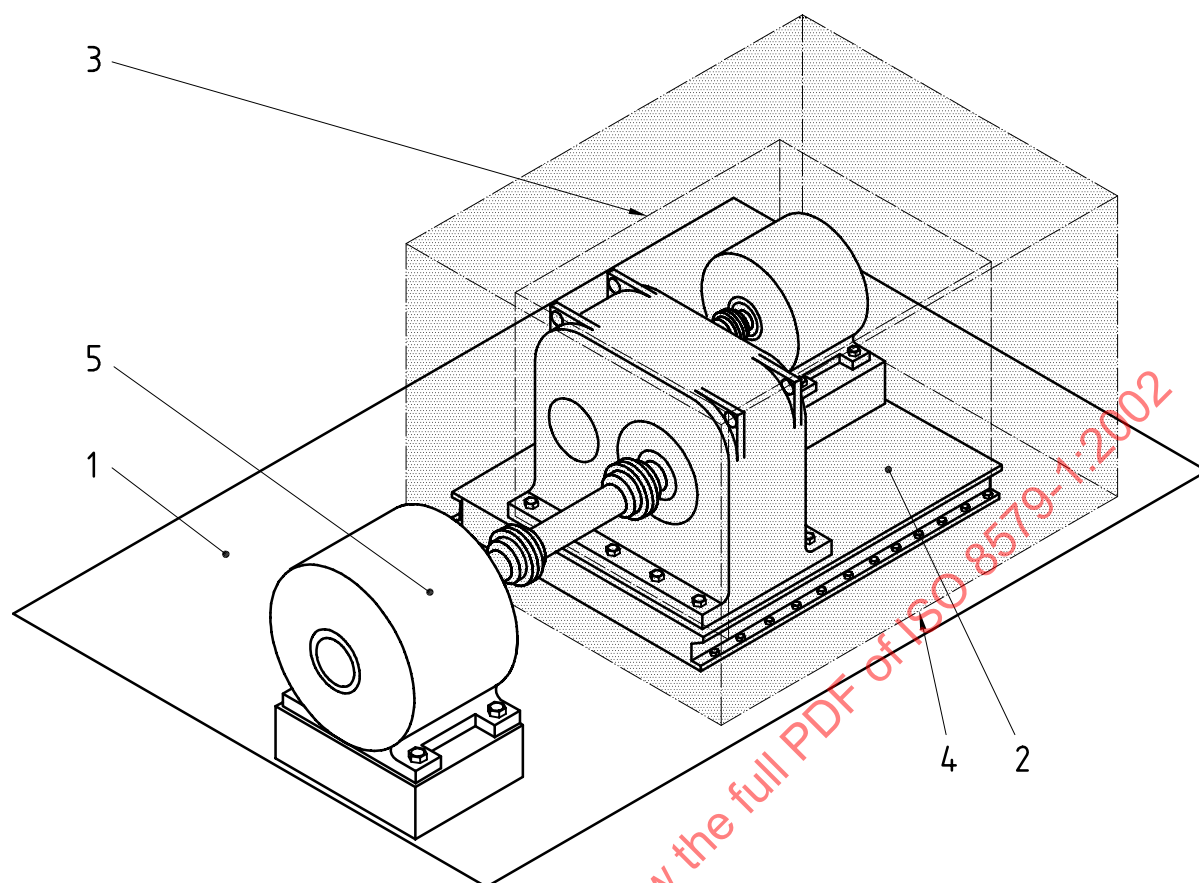
For typical measurement surfaces, see Figures 1 to 3. Measurement surfaces terminate at reflecting planes, which lie at or within the measurement distance.



Key

- 1 Test floor
- 2 Gear unit
- 3 Reference box
- 4 Measurement surface
- 5 Motor
- 6 Load

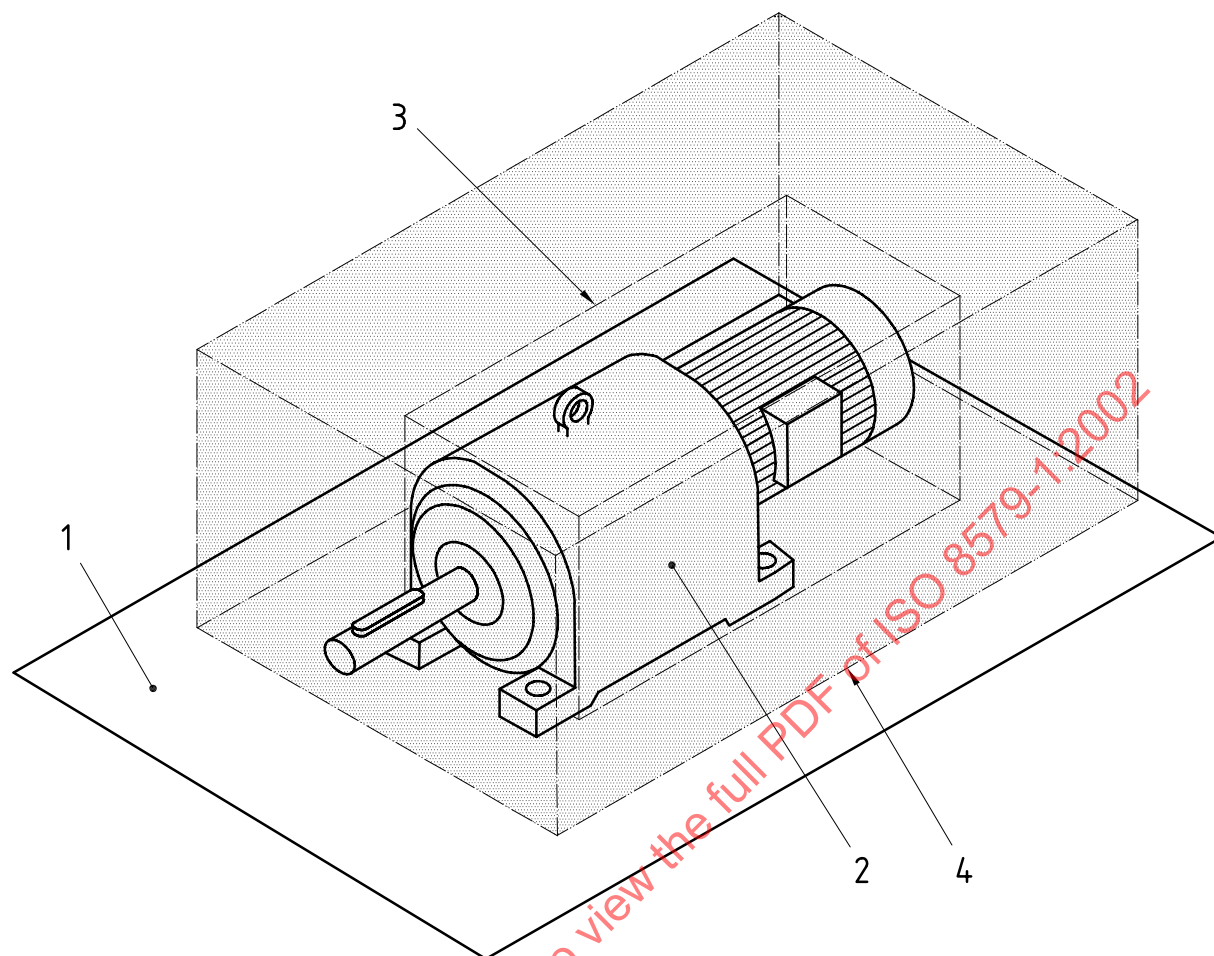
Figure 1 — Reference box and measurement surface for gear unit



Key

- 1 Test floor
- 2 Gear unit
- 3 Reference box
- 4 Measurement surface
- 5 Load

Figure 2 — Reference box and measurement surface for gear-drive system



Key

- 1 Test floor
- 2 Gear unit
- 3 Reference box
- 4 Measurement surface

Figure 3 — Reference box and measurement surface for gearmotor

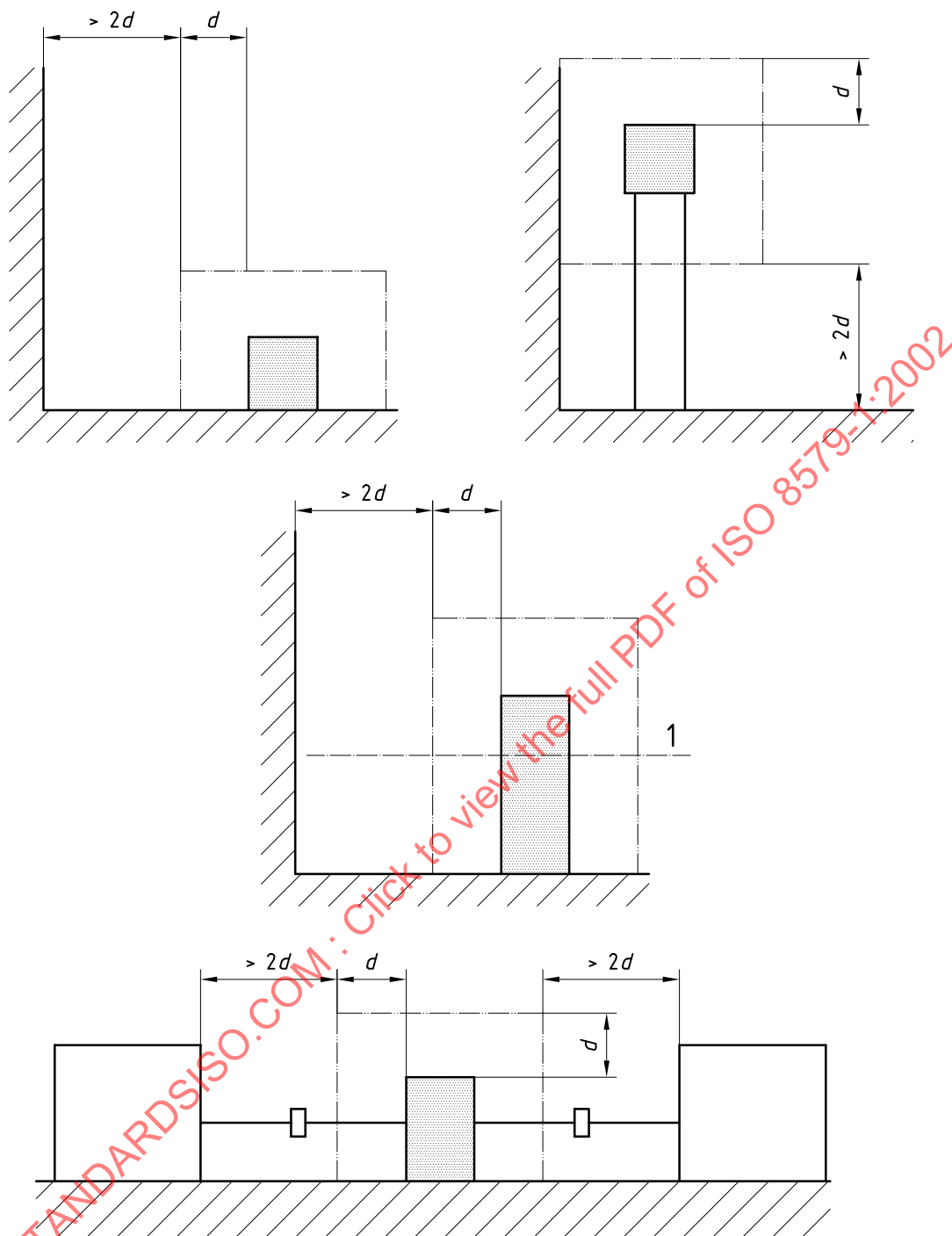
5.3.4 Position of microphones and intensity probes

The positions of the microphones and intensity probes on the measurement surface shall be those specified by the measurement standard used.

Typical microphone positions for sound pressure measurements are shown in Figures 4 to 11. The locations for intensity probes and the distance, d , may be different for intensity measurements.

Caution should be taken in selecting the proper positions of the microphones and intensity probes. They shall be chosen with care and should be appropriate for the arrangement of the machinery and location of walls or sound reflecting surfaces. Otherwise, the determined sound power may not accurately represent that radiated from the gear configuration only.

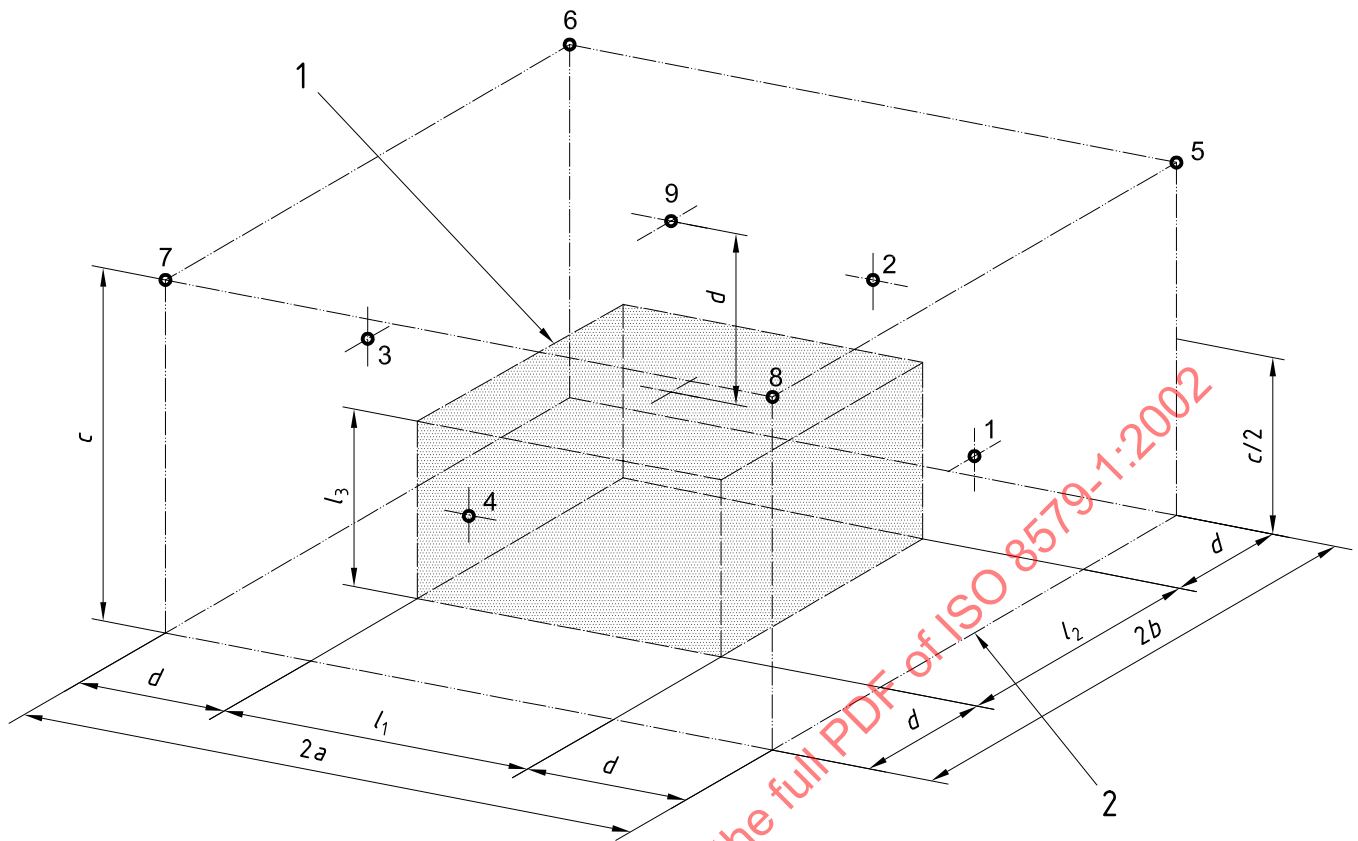
Additional examples of practical microphone positions for various types and sizes of gear are given in annex A.



Key

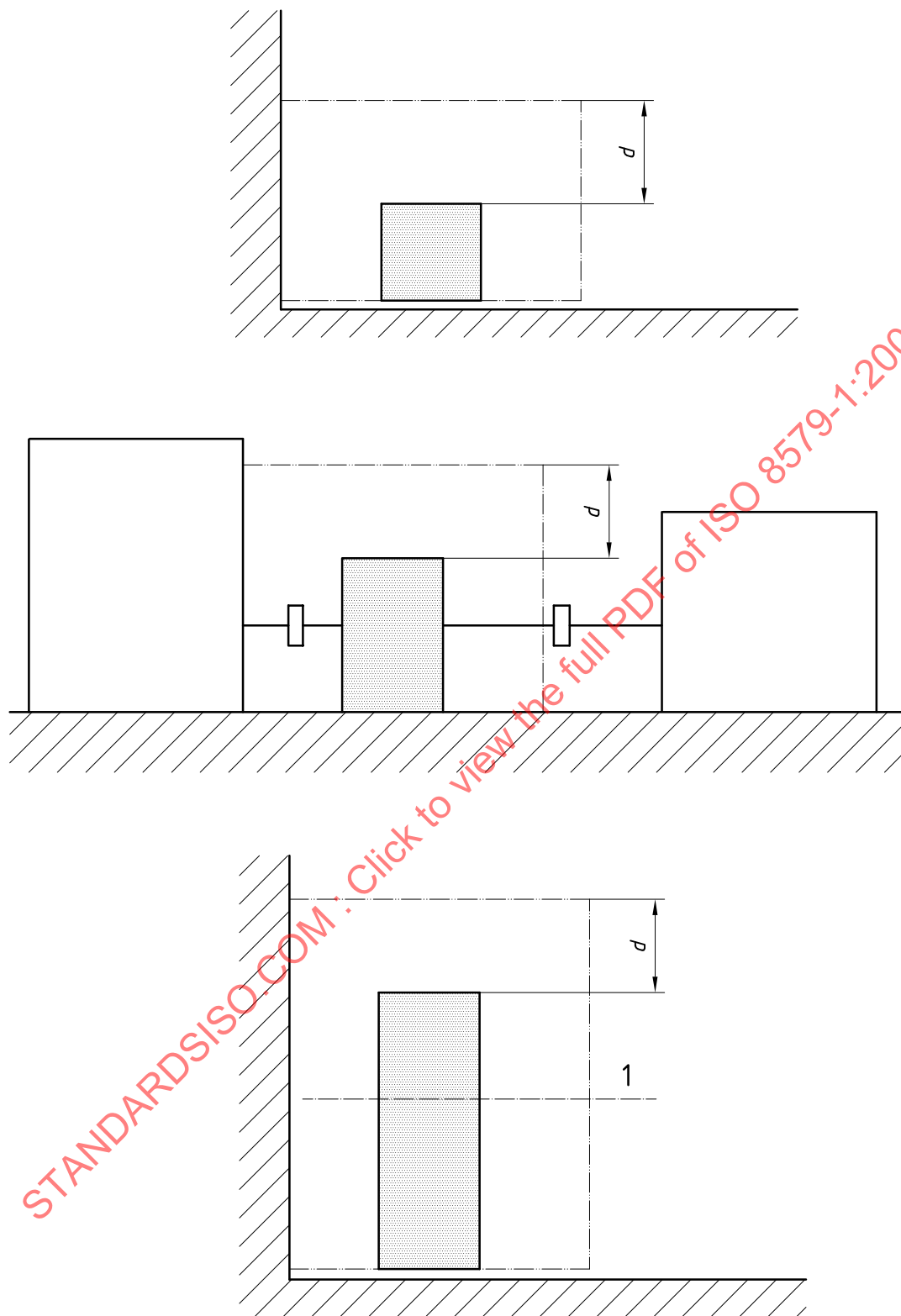
1 Flooring grill

Figure 4 — Examples of machinery mounted on floor or by a wall

**Key**

- 1 Reference box
- 2 Measurement surface

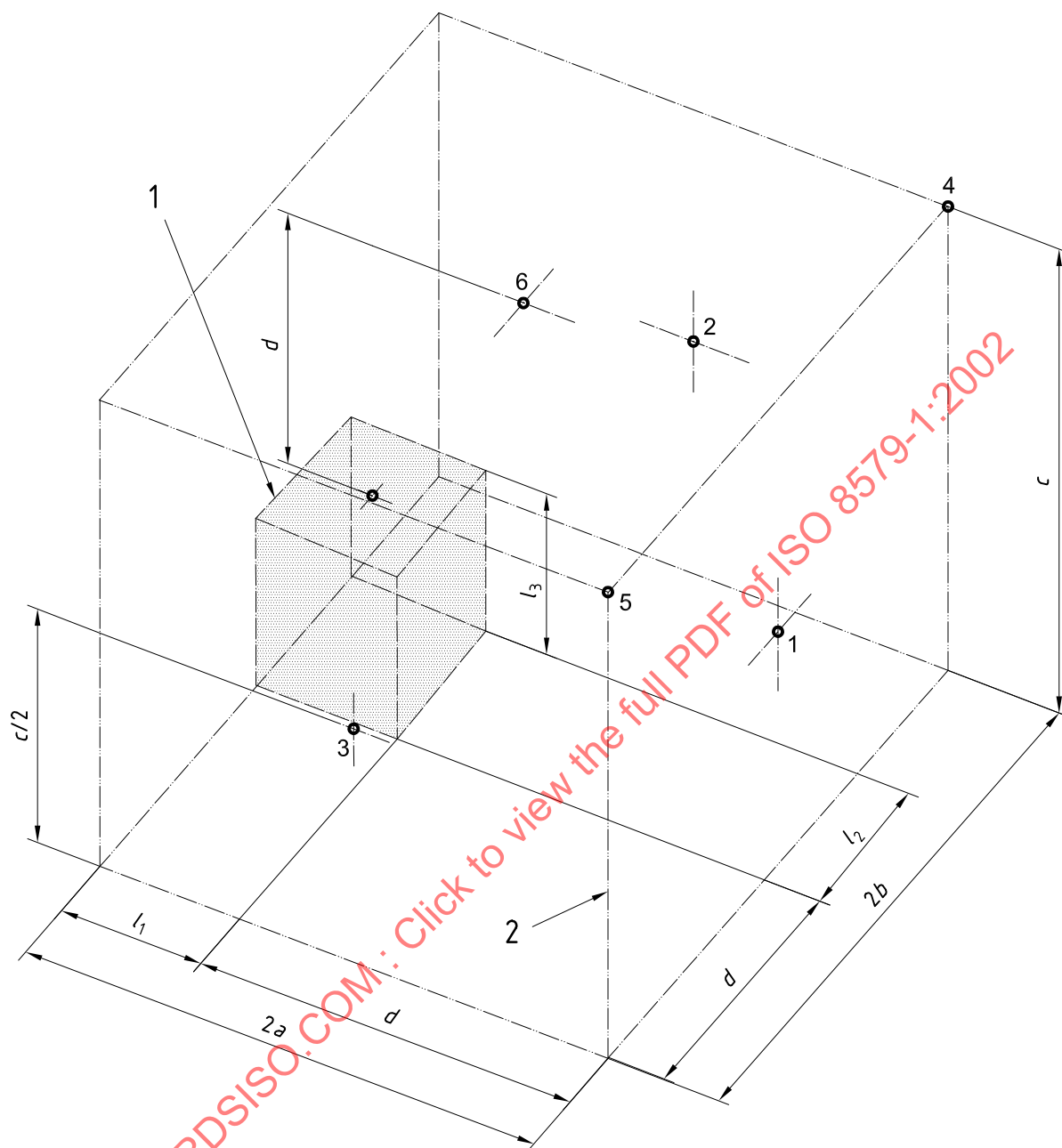
Figure 5 — Measurement points arrangement for Figure 4



Key

1 Flooring grill

Figure 6 — Examples of machinery mounted on floor and near a wall

**Key**

- 1 Reference box
- 2 Measurement surface

Figure 7 — Measurement points arrangement for Figure 6

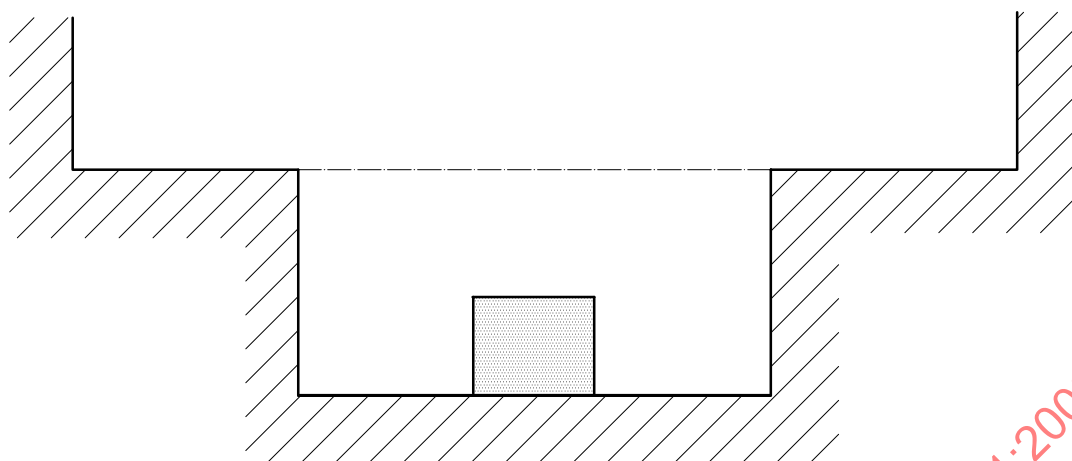
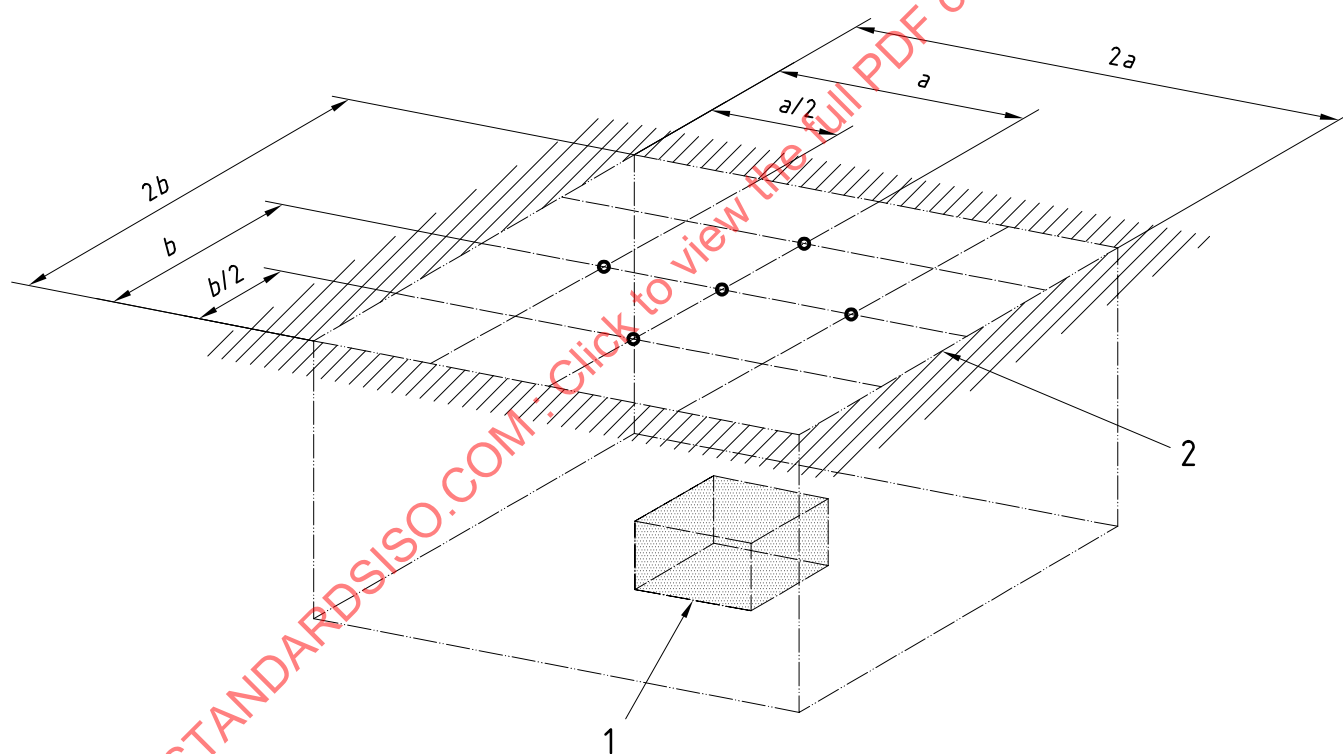


Figure 8 — Example of machinery mounted in a pit with hard, sound-reflecting walls



Key

- 1 Reference box
- 2 Measurement surface

Figure 9 — Measurement points arrangement for Figure 8

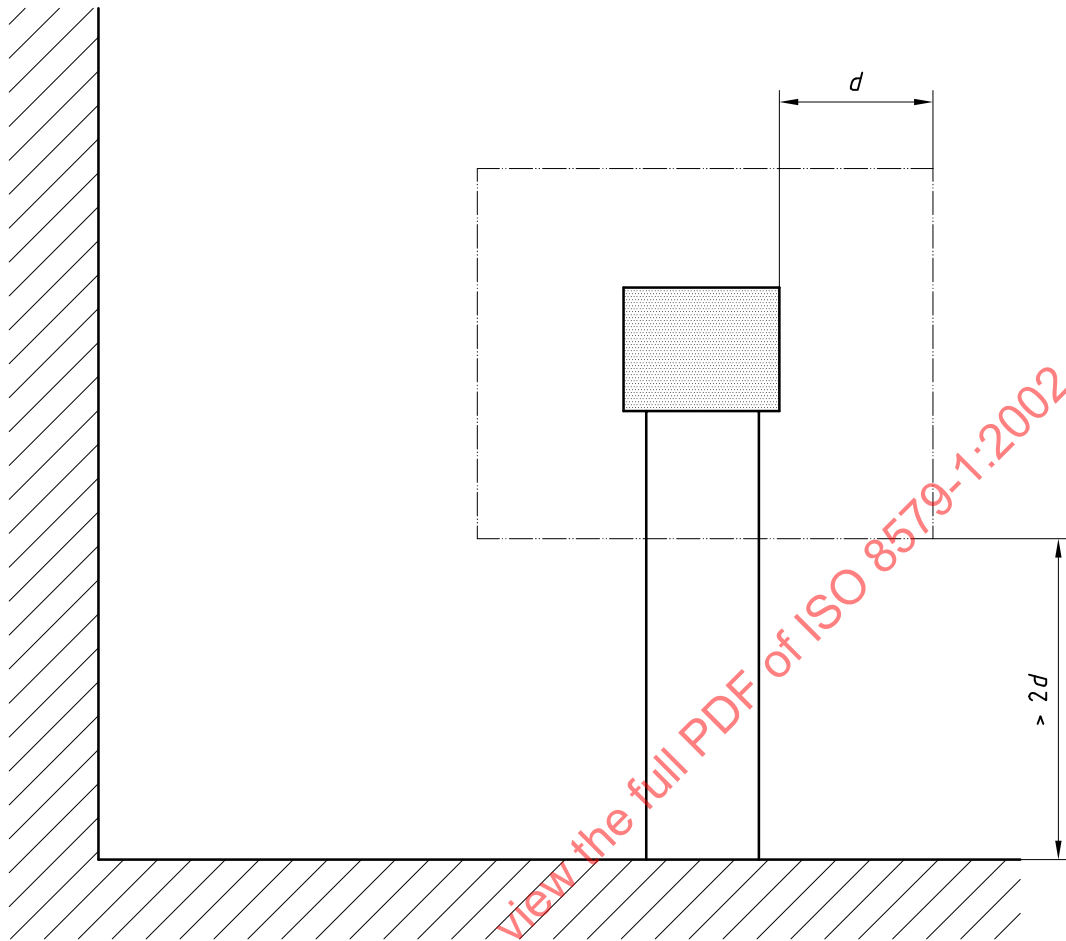
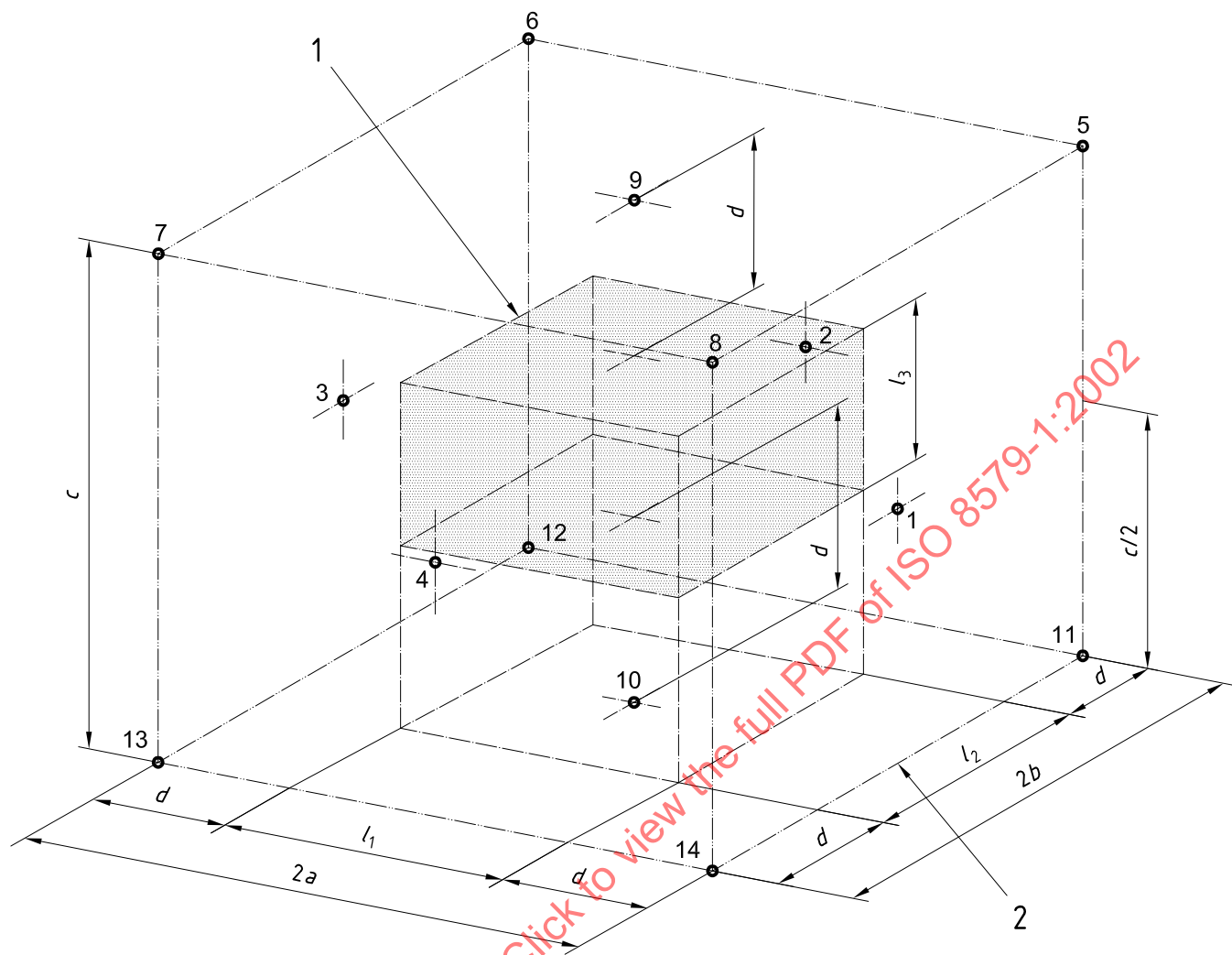


Figure 10 — Example of machinery mounted at considerable distance from sound-reflecting surface

**Key**

- 1 Reference box
- 2 Measurement surface

Figure 11 — Measurement points arrangement for Figure 10

5.4 Measurement uncertainty

The measurement uncertainty shall be in accordance with the relevant standard and the corresponding grade used.

NOTE Measurements may be distorted under difficult conditions (by vibrations, electrical and magnetic fields, wind or gas streams, abnormal temperatures etc.).

6 Determination of emission sound pressure level

6.1 Basic standard to be used

The A-weighted sound pressure level at the work station (see 6.2) shall be determined using ISO 11203:1985 [method using a value calculated from Q ($Q = Q_2$)] that prescribes a derivation of the A-weighted sound pressure

level from the A-weighted sound power level. It represents the average A-weighted sound pressure level over the measurement surface enveloping the gear configuration defined in 5.3.3.

6.2 Work station

Since gear units/motors have no identifiable work stations, the work station is defined conventionally as being at a point a distance of 1 m from the reference box defined in 5.3.2.

7 Installation and mounting conditions

7.1 Grade of accuracy

The grade of accuracy is dependent upon the installation and mounting conditions. For a required grade of accuracy, sound intensity measurements are much less demanding than for a sound pressure measurement, since the sound intensity method strongly eliminates the effect of extraneous sources.

7.2 Acoustic environment

7.2.1 General

Installation and mounting conditions for the gear configurations are dependent upon the acoustic environment.

7.2.2 Specific facility intended for acoustic measurements

The test facility is an area specifically intended for acoustic measurement. The test facility shall fulfil the following minimum requirements:

- use of low-sound driving and braking devices;
- avoidance of standing waves effects;
- insulation of structure-borne sound between the gear configuration and supporting structure;
- avoidance of mechanical resonance;
- in the case of gear units, insulation by acoustical barrier or enclosure of the transmission elements, braking devices and drive/motor.

A facility may be qualified as specifically designed for sound measurement if it yields grade 2 measurements.

7.2.3 Shop test stand

Acoustic feedback from loading in the case of gear units and braking devices outside the inlet/outlet flanges and the connected auxiliary systems shall not influence the measurement of the sound emission of the gear unit/motor. Low-sound braking devices should preferably be used.

Consideration should be given to

- acoustic lagging of connected systems,
- operating at a minimum of other sound sources,
- temporary screening of the driver/motor in the case of gear units, transmission elements and braking devices, and
- temporary application of absorbing material on reflecting surfaces.

7.2.4 On-site

Wherever possible, the following actions to improve the acoustic environment shall be taken:

- operating at a minimum of other sound sources;
- temporary screening of the driver/motor in the case of gear units, transmission elements and braking devices;
- temporary application of absorbing material on reflecting surfaces.

8 Operating conditions during sound measurements

8.1 General

Unless otherwise agreed by the purchaser and the manufacturer/supplier, the conditions of 8.2 to 8.4 shall apply.

If the normal operating conditions cannot be met during the tests due to power limitations or other reasons, the reduced conditions should be agreed upon between the manufacturer and the purchaser.

8.2 Test conditions during sound measurement

The test conditions are the following:

- the gear configuration shall be tested in its intended direction of rotation or, if reversible, in both directions;
- the measurements shall be conducted using the operating lubrication system and the lubricant viscosity equivalent to the operating viscosity;
- the measurements shall be conducted when the gear configuration is operating within its design temperature range.

8.3 Operating speed

The gear configuration shall be tested at its intended operating speed.

A gear configuration intended for service over a range of operating speeds shall be tested at speeds which span the operating range, unless otherwise agreed upon between manufacturer and purchaser.

8.4 Operating load

The measurement shall be made while the gear configuration is at nominal or at an agreed upon load. This operating point can be defined as one of the following:

- rated conditions (= guaranteed conditions) when specified for the gear configuration;
- contractual conditions (other than rated conditions);
- nominal conditions at the point of best efficiency.

NOTE If the agreed condition is at low load (idling), care needs to be taken if a rattle exists that is difficult to interpret.

9 Information to be recorded

The information to be recorded includes all the information required by the sound measurement standards used for the test.

10 Information to be reported

The information to be included in the test report is at least the information the manufacturer requires to prepare a sound test declaration or that the user requires to verify the declared values.

As a minimum, the following information shall be included:

- a) full identification of the gear configuration (see 4.1);
- b) technical characteristics of the gear configuration;
- c) reference to this part of ISO 8579 and to the basic sound emission standard used, chosen from among those allowed by this part of ISO 8579; if the power of the gear configuration is such that this sound test code recommends use of a grade 2 standard, but a grade 3 standard is used instead, the reasons why it has not been possible to use a grade 2 standard shall be stated;
- d) a statement to the effect that all requirements of this sound test code, and of the basic standard used, have been fulfilled;
- e) descriptions and operational conditions, including a dimensional sketch of the test room, the arrangement of the gear unit, the position of measurement points, the distance of measurement points from the gear unit surfaces, and data from measurement points (see clause 7);
- f) a list of the measurement equipment used, by make, type and calibration status;
- g) the sound emission values obtained; A-weighted sound pressure or power levels and, when appropriate, frequency-band sound power levels.

11 Declaration and verification of sound emission values

The declaration of the sound emission values is the sole responsibility of the manufacturer. It shall be made in such a fashion that the values can be verified according to ISO 4871.

The declaration of both the A-weighted sound power level and A-weighted sound pressure level, at the relevant work station as defined in 6.2, is recommended. The sound declaration shall mention explicitly the fact that the sound emission values have been obtained according to this sound test standard and indicate the basic standard used for the determination of the sound power level. If such a statement could not be justified, the sound declaration shall indicate clearly the deviation from this sound test standard or from the basic standards used, or both.

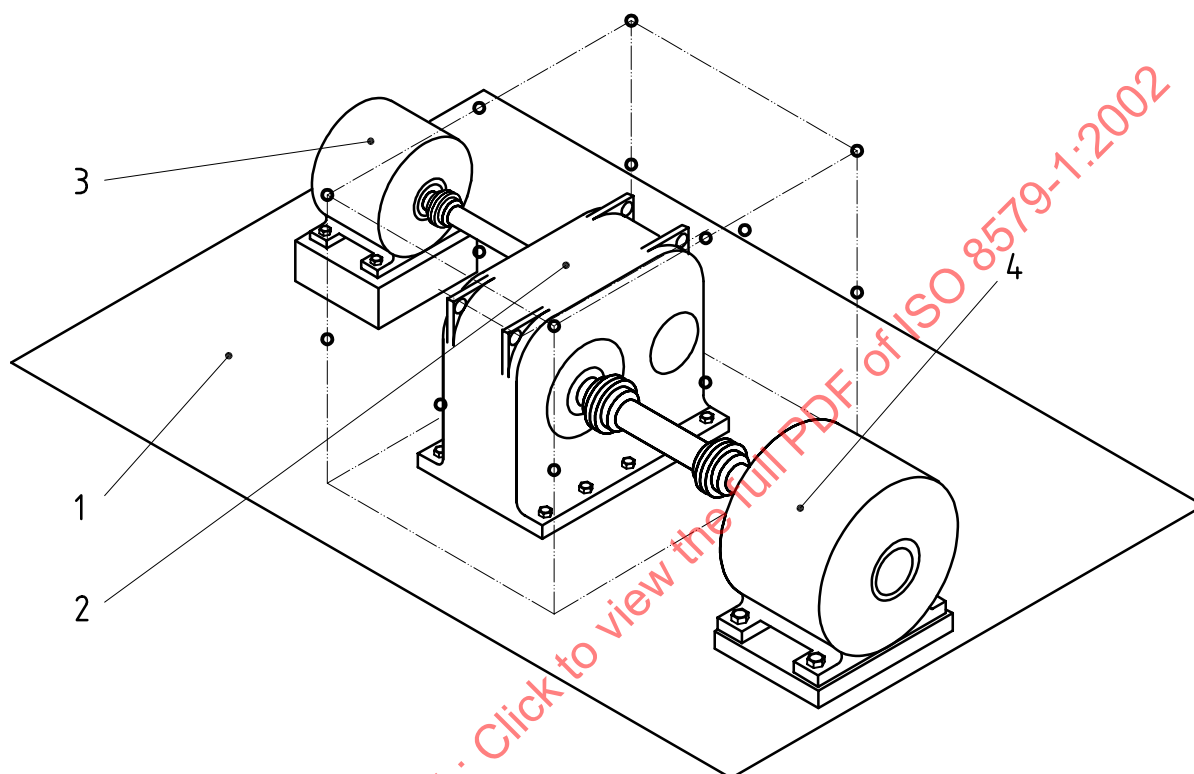
Use of the method for declaration given in annex A of ISO 4871:1996 is recommended.

If performed, verification shall be conducted using the same mounting and operating conditions as those used for the initial determination of the sound emission values. It shall be made on a single machine in accordance with 6.2 of ISO 4871:1996.

Additional sound emission quantities, including sound power levels in octave bands and measured values of the sound emission quantities declared, may also be given in the sound declaration. In this case, care shall be taken to avoid confusion between these additional sound emission data and the declared sound emission values.

Annex A (informative)

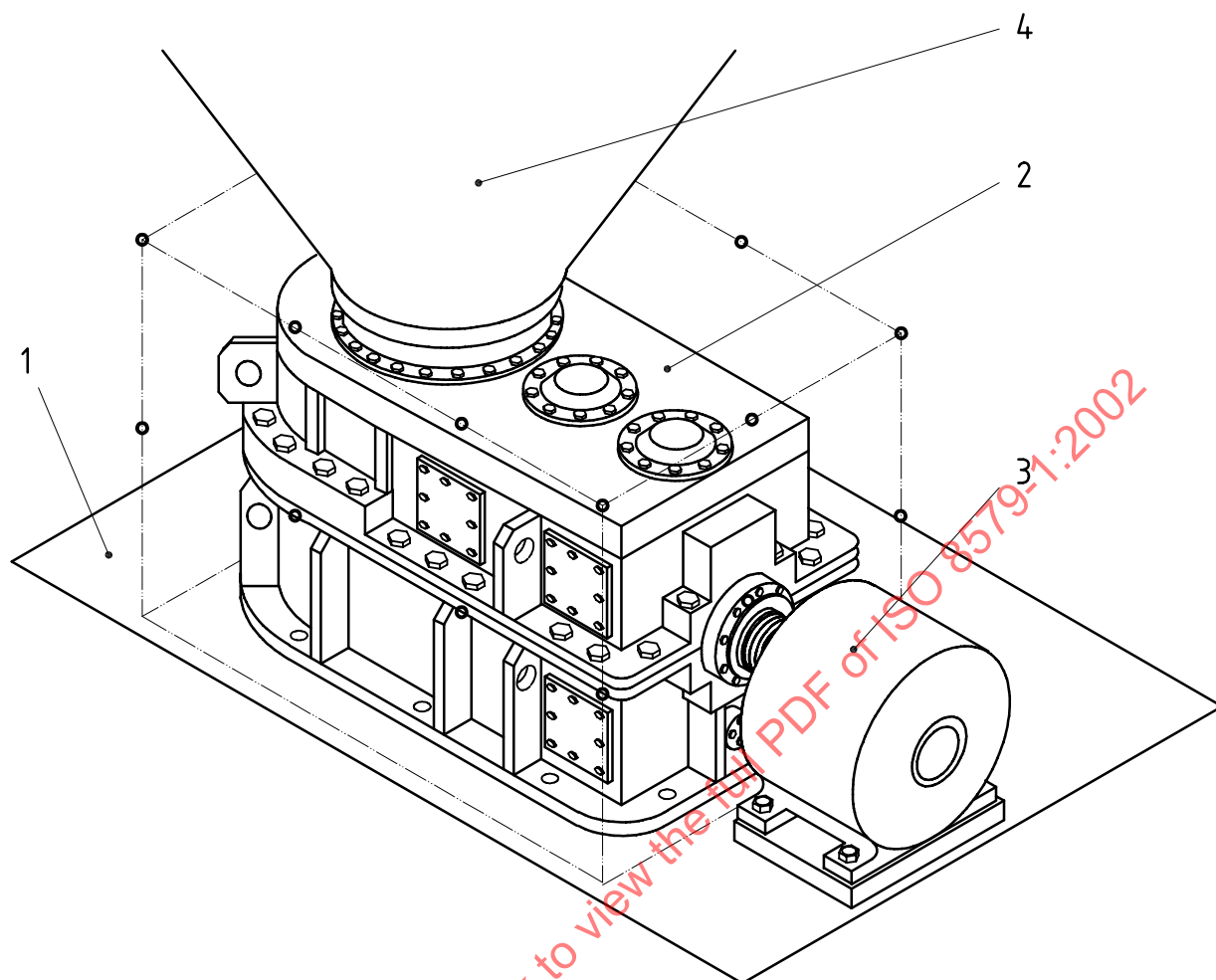
Examples of microphone positions on the measurement surface for different gear types and sizes



Key

- 1 Test floor
- 2 Gear unit
- 3 Motor
- 4 Load
- Microphone position

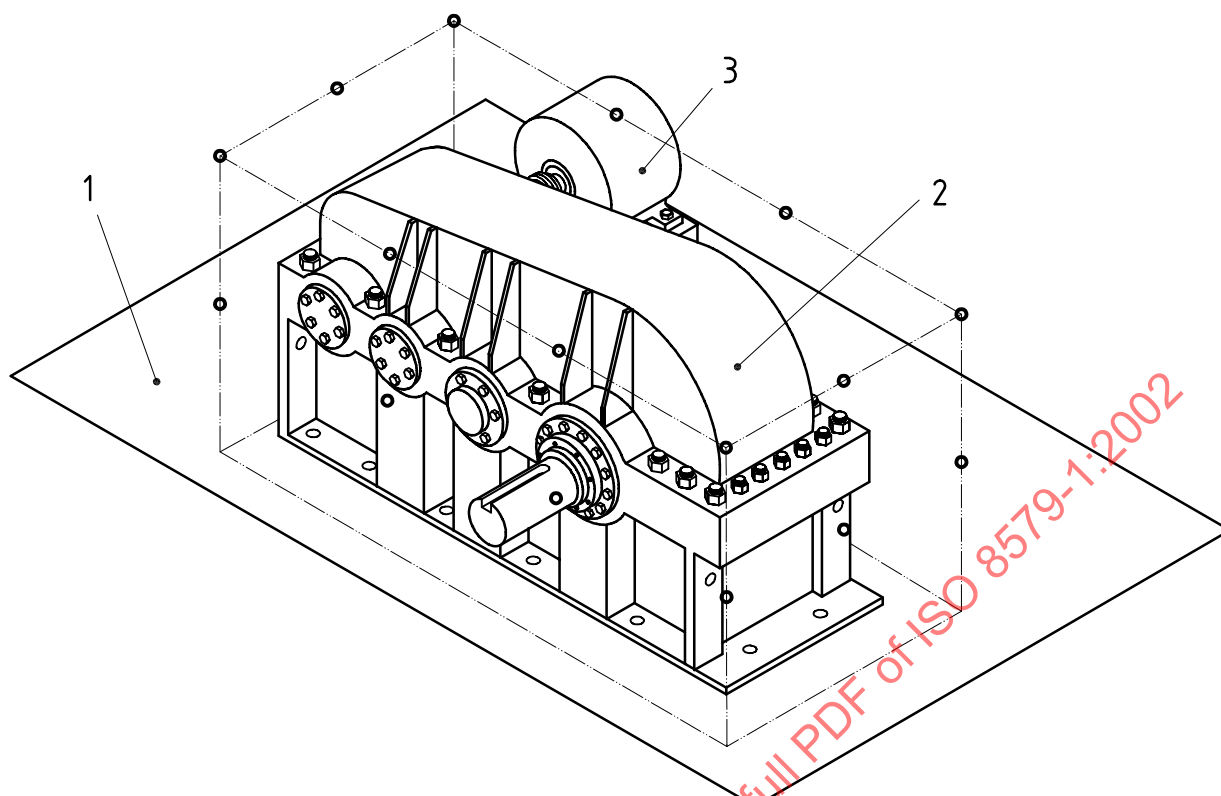
Figure A.1 — Single reduction gear unit

**Key**

- 1 Test floor
- 2 Gear unit
- 3 Motor
- 4 Load

● Microphone position

Figure A.2 — Triple reduction, bevel helical mill drive

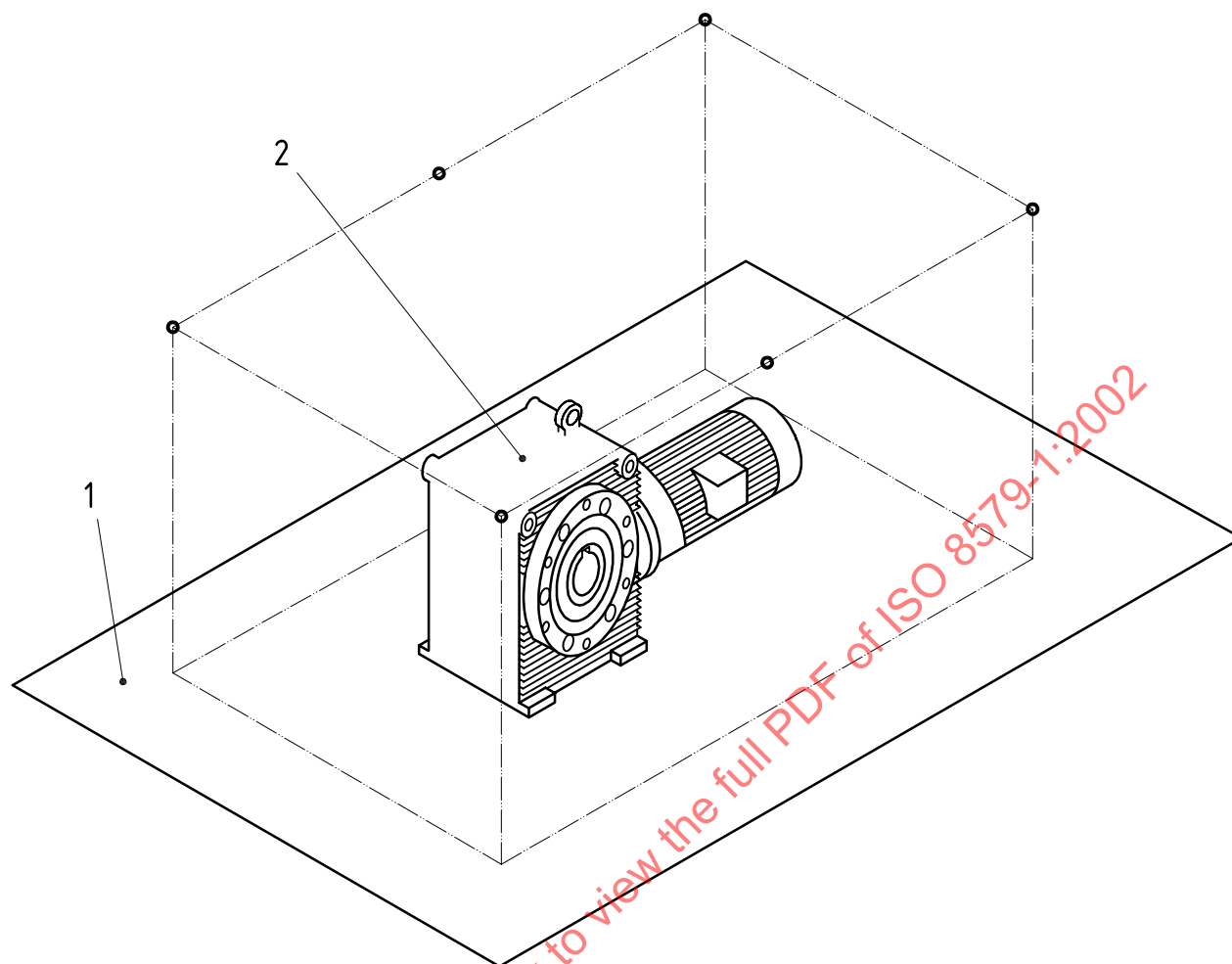


Key

- 1 Test floor
- 2 Gear unit
- 3 Motor

● Microphone position

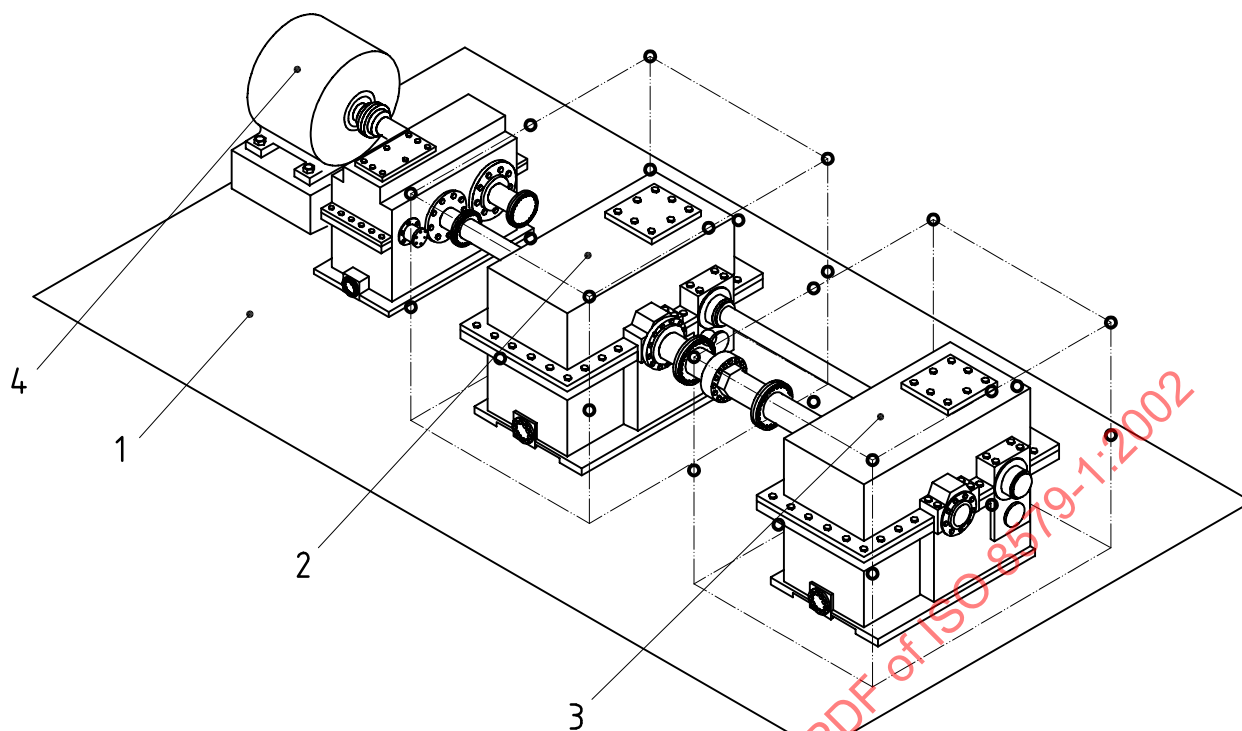
Figure A.3 — Triple reduction, parallel shaft drive

**Key**

- 1 Test floor
- 2 Gearmotor

● Microphone position

Figure A.4 — Helical worm shaft-mounted drive

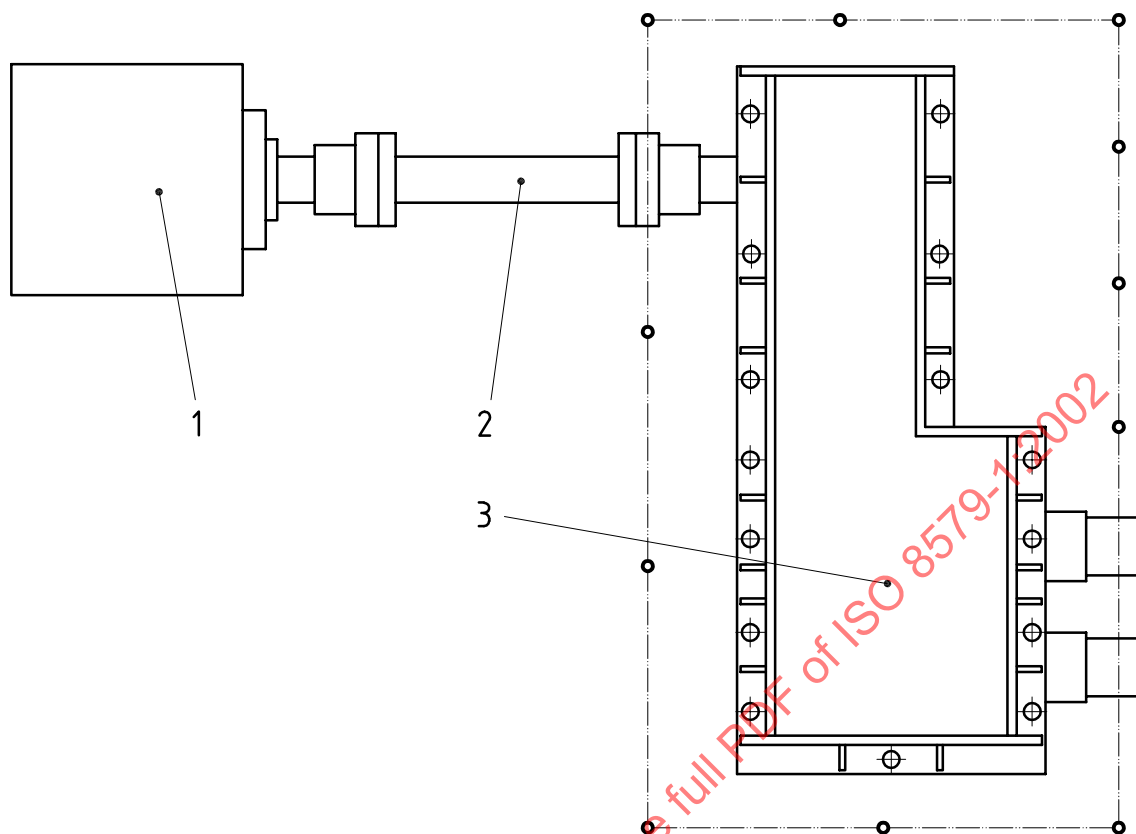


Key

- 1 Test floor
- 2 Gear unit 1
- 3 Gear unit 2
- 4 Motor

● Microphone position

Figure A.5 — High-speed “back to back” shop test

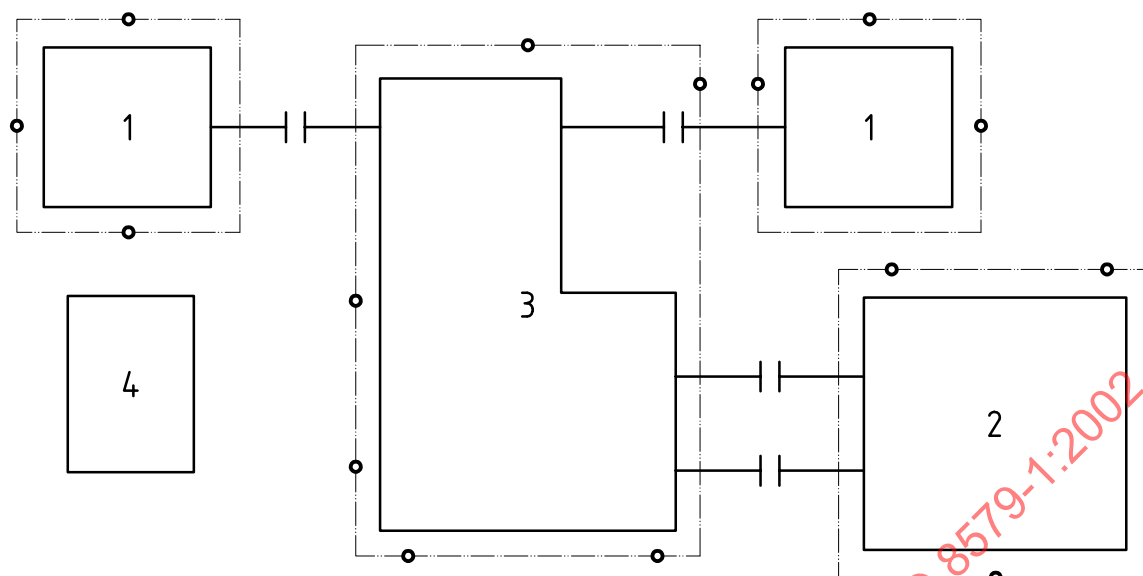


Position of microphone in measuring cross-section

Key

- | | | | |
|---|------------------------------|---|---------------------|
| 1 | Motor | ● | Microphone position |
| 2 | Coupling | | |
| 3 | Gear unit (for rubber mixer) | | |

Figure A.6 — Practical shop measurement set-up



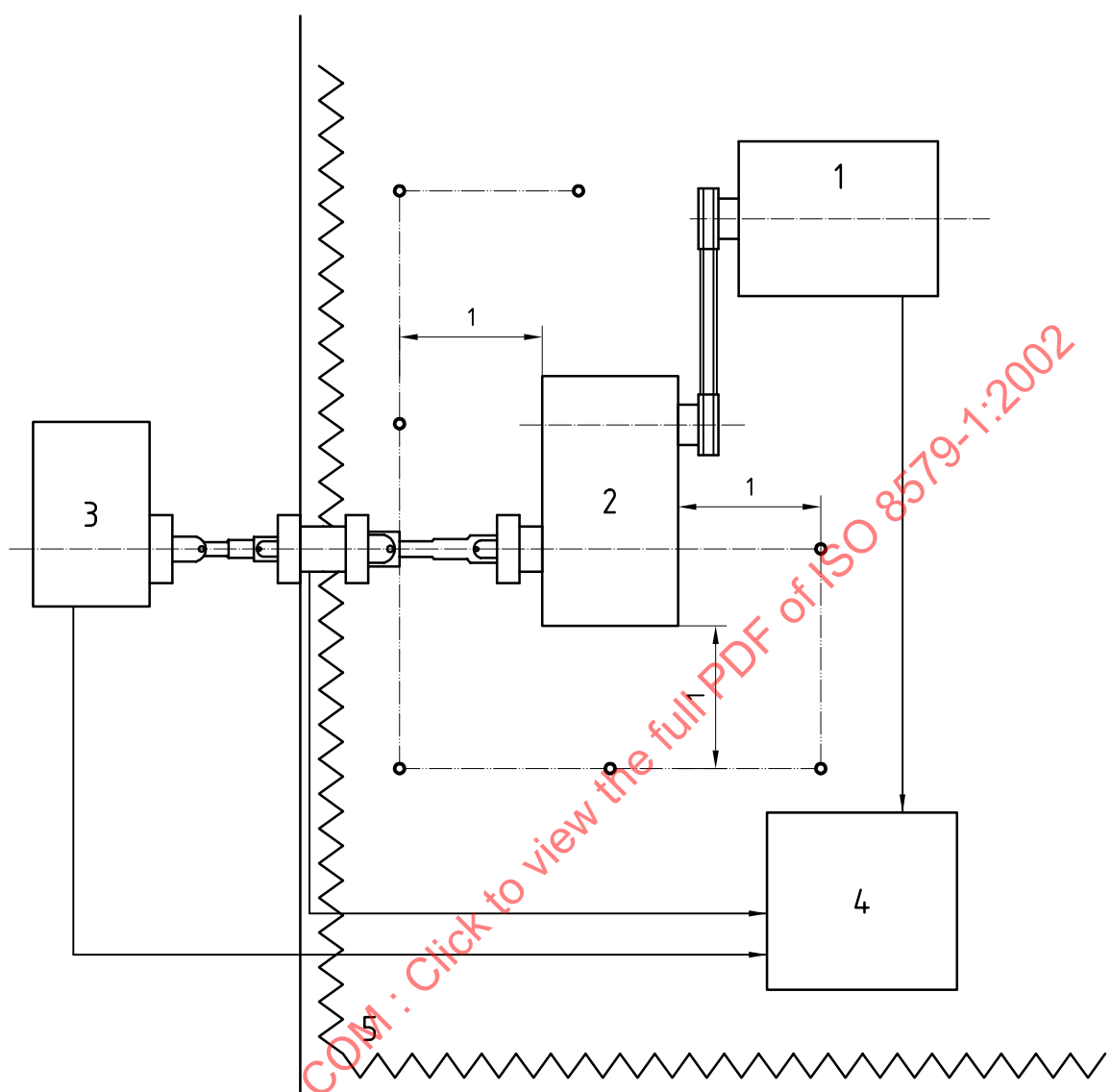
Intensity probe envelope in sound measuring cross-section for each component of interest

Key

- | | | | |
|---|--------------------|---|---------------------|
| 1 | Motor | ● | Microphone position |
| 2 | Mixer | | |
| 3 | Gear unit | | |
| 4 | Lubrication system | | |

Figure A.7 — Typical on-site measurement set-up for determining component levels

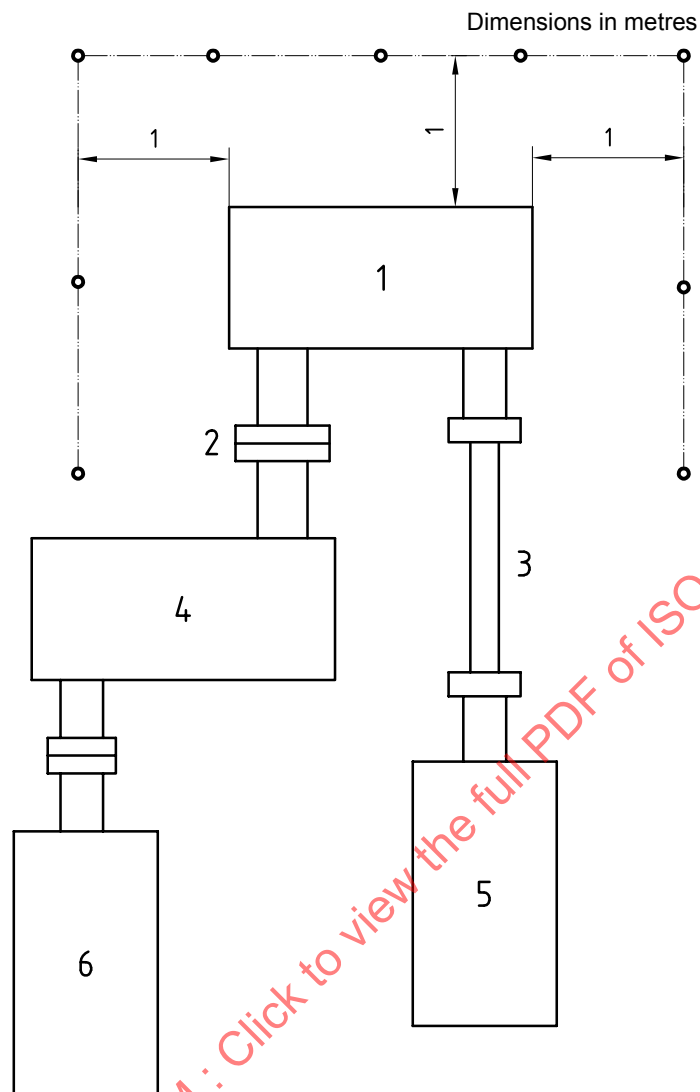
Dimensions in metres

**Key**

- 1 Motor
- 2 Gear unit
- 3 Load
- 4 Speed torque control
- 5 Absorption wall

● Microphone position

Figure A.8 — Schematic of test cell set-up



Microphone position in sound measuring cross-section where speed-increasing gear is quiet

Key

- | | | | |
|---|----------------------------|---|---------------------|
| 1 | Gear unit (test object) | ● | Microphone position |
| 2 | Gear tooth coupling | | |
| 3 | Floating shaft | | |
| 4 | Speed-increasing gear unit | | |
| 5 | Drive motor | | |
| 6 | Generator | | |

Figure A.9 — Schematic test layout of shop floor load test

Annex B (informative)

Typical sound levels for different gear types and sizes (sound power and sound pressure)

B.1 Purpose

The purpose of this annex is to present typical sound levels for enclosed gear configurations measured.

NOTE Sound power and sound pressure are different data. The results of each in decibels cannot be directly compared.

B.2 Typical sound pressure levels

B.2.1 General

The sources of generated sound in a gear-driven system are important. However, the levels generated and the methods of measurement become the points of major interest when determining whether a system will meet a specification. The gear industry has had years of experience measuring sound, both on the test stand and in field installations. This experience has indicated the sound pressure levels that can be expected on qualification spin or load tests. These sound pressure levels can be obtained from test results of identical or comparable units, or from empirical data extrapolated from similar equipment, or from both. The levels generally will not include driving- or driven-equipment sound and system influences. When a gear unit is actually installed, the prediction or estimation of its sound pressure level is difficult, since the gear unit will then be part of a total acoustic system that includes, in addition to the gear unit, the prime mover, driven equipment, gear unit mounting and surrounding acoustical environment. Some insights into this problem can be gained by examining the effect of certain system parameters, such as speed and load.

B.2.2 Typical maximum data

Typical maximum sound pressure levels for representative types of gear unit are shown in Figures B.1 to B.7, for information only. The typical maximum curves of Figures B.1 to B.3 were established based on the measured sound pressure levels of the gear units given by the points in the figures. The curves for gearmotors in Figure B.2 were obtained by adding estimated electric motor sound pressure levels to gear unit sound levels.

B.2.3 Speed effects

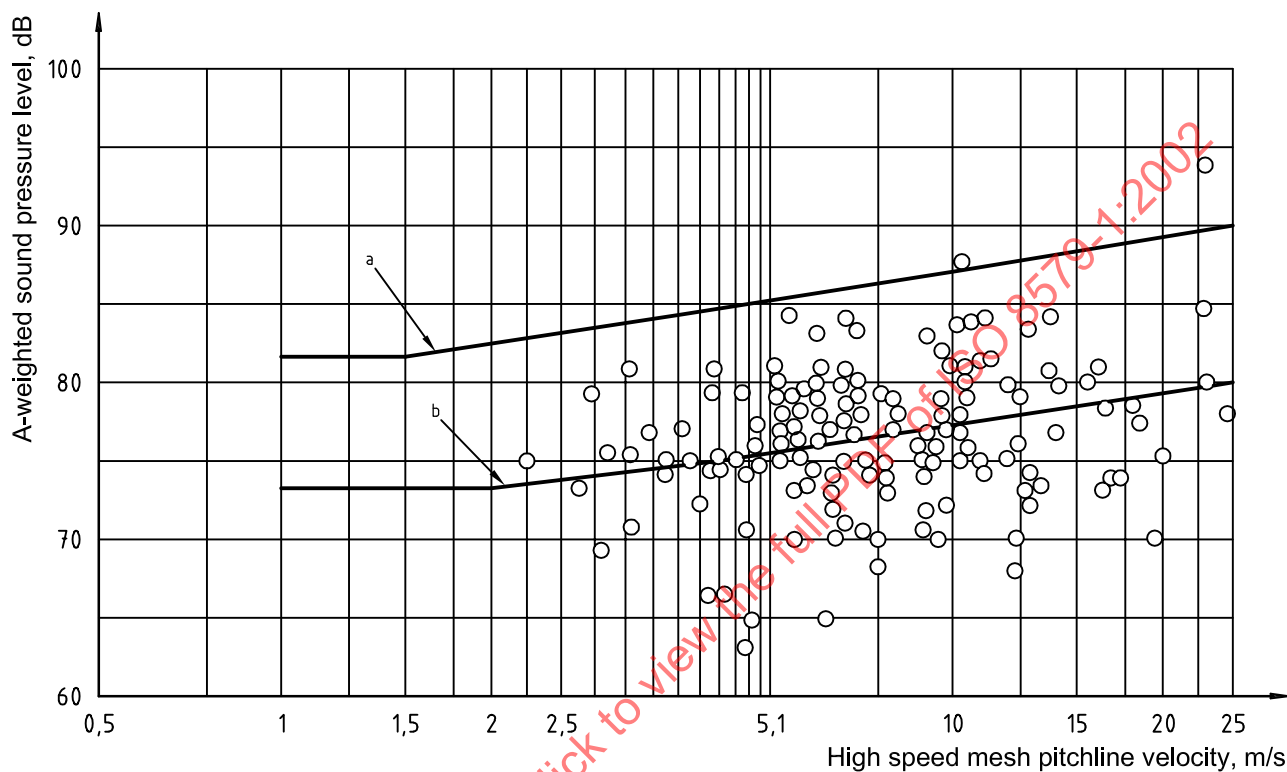
Typical data for the effect of speed (input revolutions per minute) on the gear unit sound pressure level is presented in Figure B.4.

B.2.4 Load effects

One of the most significant operating parameters affecting the level of gear unit sound is load. Much of the experimental literature to date indicates an increase in sound due to an increase in load (see Figure B.5). Some data has indicated as much as a 20 dB increase for spur gearing between a load and no-load (spin) test. However, empirical data collected throughout the gear industry indicates increased sound level does not always accompany increased loading. In some cases, even the reverse occurs, i.e. when the tooth geometry has been modified for loaded deflections and operating temperatures. Until these design loads and temperatures have been reached, the mesh action may be noisy. The average statistical difference in gear unit sound between no-load spin and full load (rated load/service factor) is an increase of approximately 4 dB(A) (see Figure B.6 — helical, herringbone, spiral bevel and worm gearing).

The maximum increase in sound between no load and full load observed was 12 dB(A). The data showed about two thirds of the units increased in sound with load. About one-fifth did not indicate a measured difference with load, and the remainder had reduced sound pressure levels with increased load.

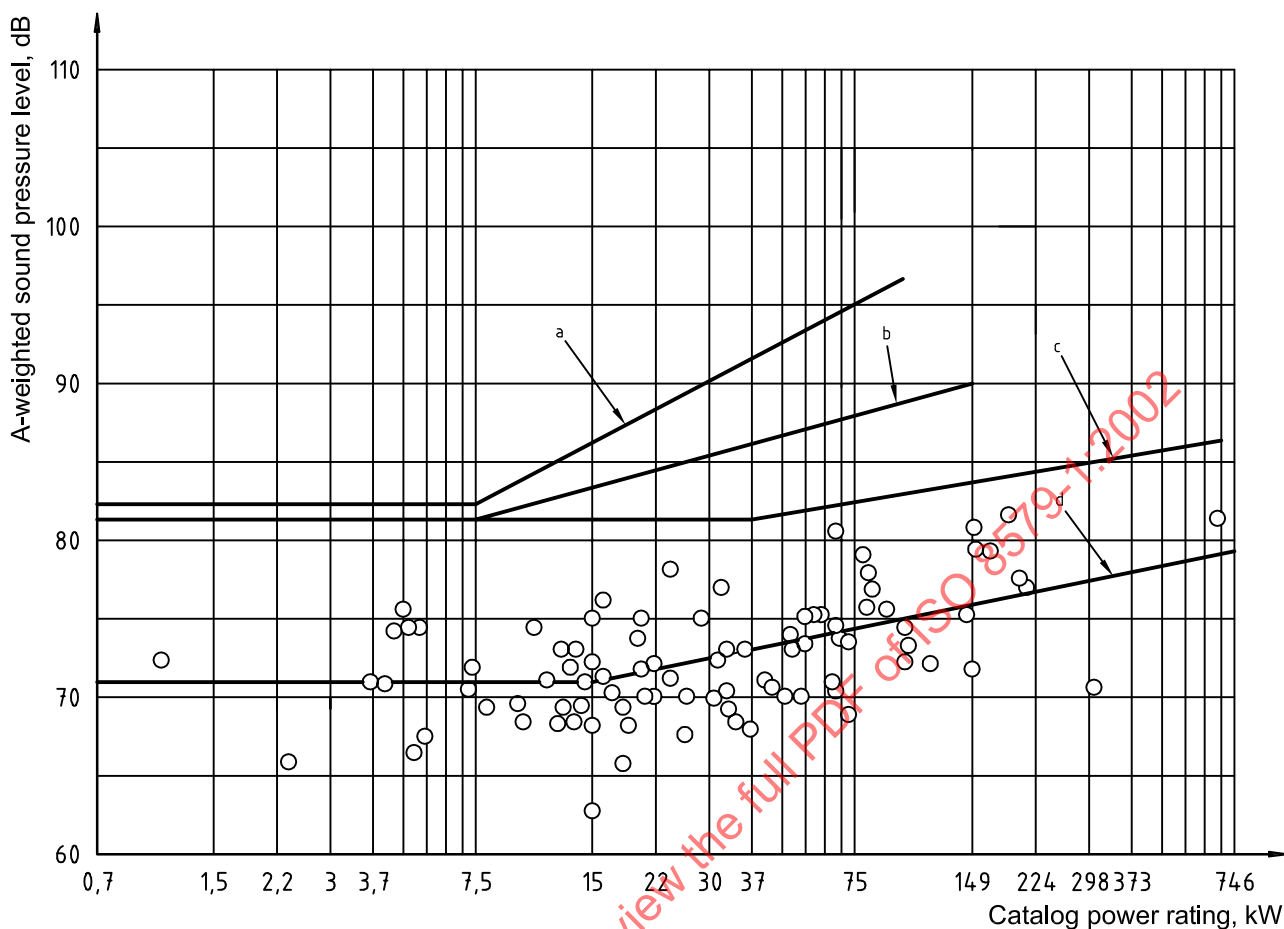
Therefore, for gears of this type, a majority showed an average increase of 4 dB(A). Only in similar gear-drive systems may this be used as a guideline for the expected difference between a shop spin test and field-installed load operation.



Enclosed helical and spiral bevel gear units — single-, double- and triple-reduction, without cooling fan

- a Typical maximum
- b Average

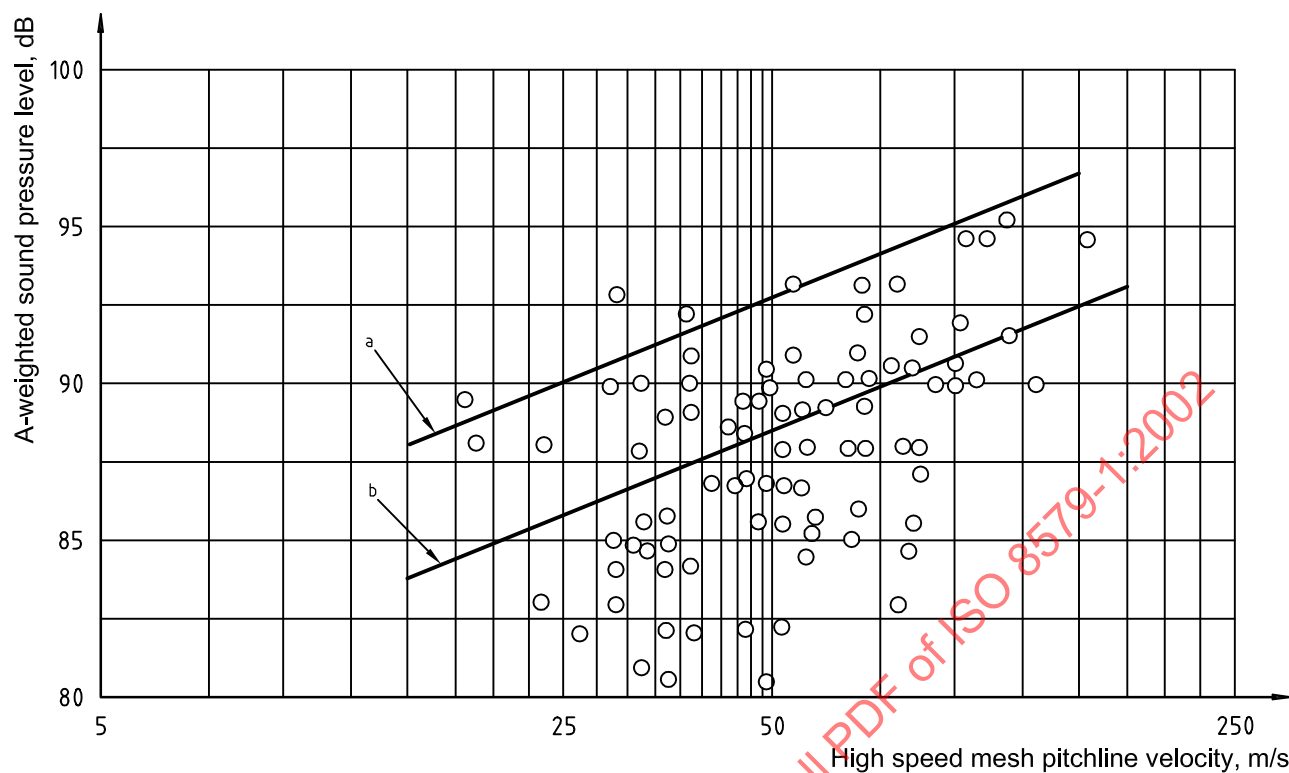
Figure B.1 — Typical maximum and average A-weighted sound pressure levels versus high-speed mesh pitch line velocity at no or light load



Gearmotors, in-line reducers and increasers — single, double and triple reduction, without cooling fan

- a Typical maximum: gearmotor (with totally enclosed fan-cooled motor, 1 800 r/min)
- b Typical maximum: gearmotor (with drip-proof motor, 1 800 r/min)
- c Typical maximum: in-line reducer and increaser (no motor)
- d Average: in-line reducer and increaser (no motor)

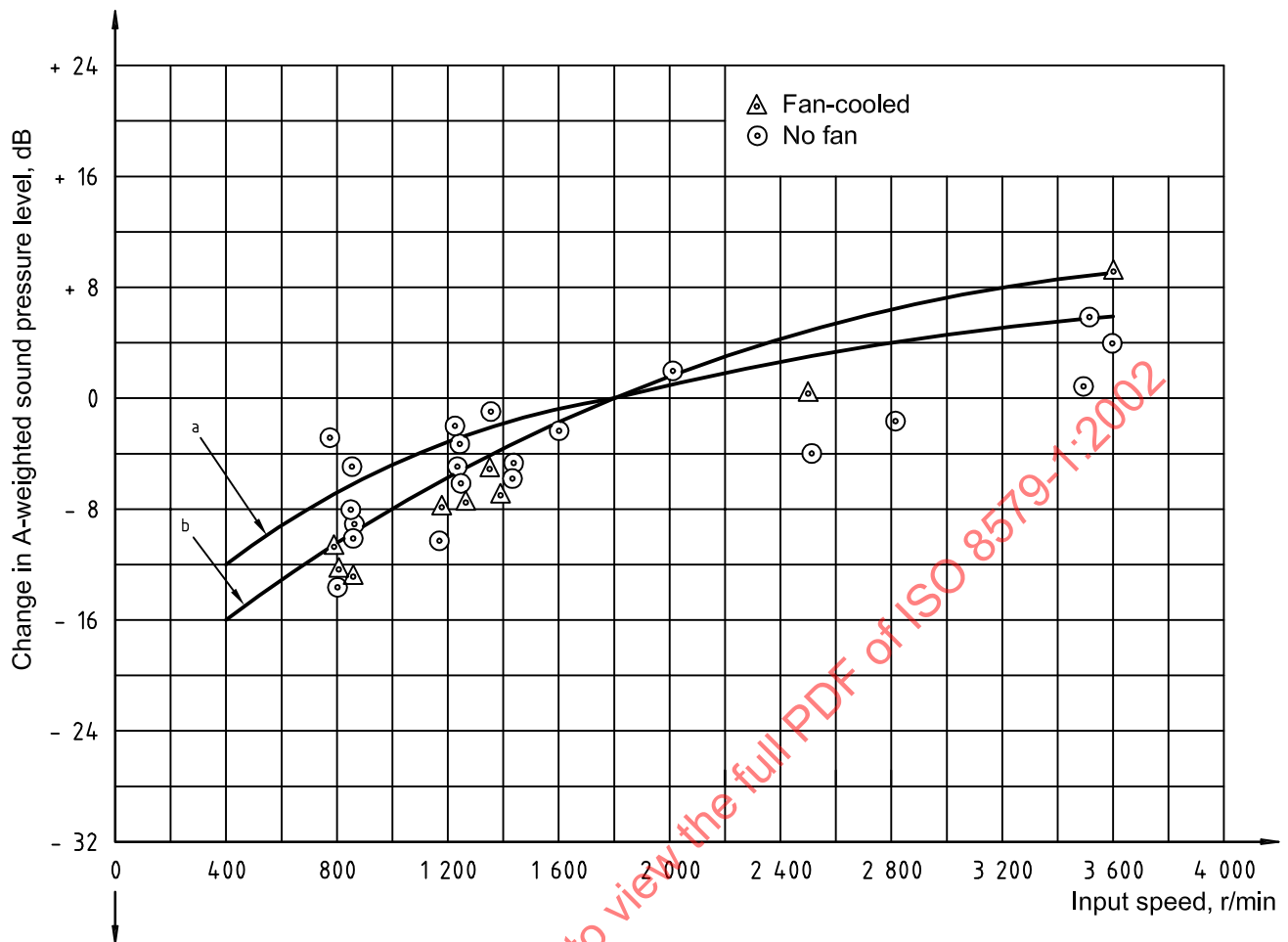
Figure B.2 — Typical maximum and average A-weighted sound pressure levels versus catalogue power ratings at no load or light load



High-speed helical and double helical single reduction gear units at full speed

- a Typical maximum
- b Average

Figure B.3 — A-weighted sound pressure level versus pitchline velocity, taken 0,9 m from housing, at no or light load

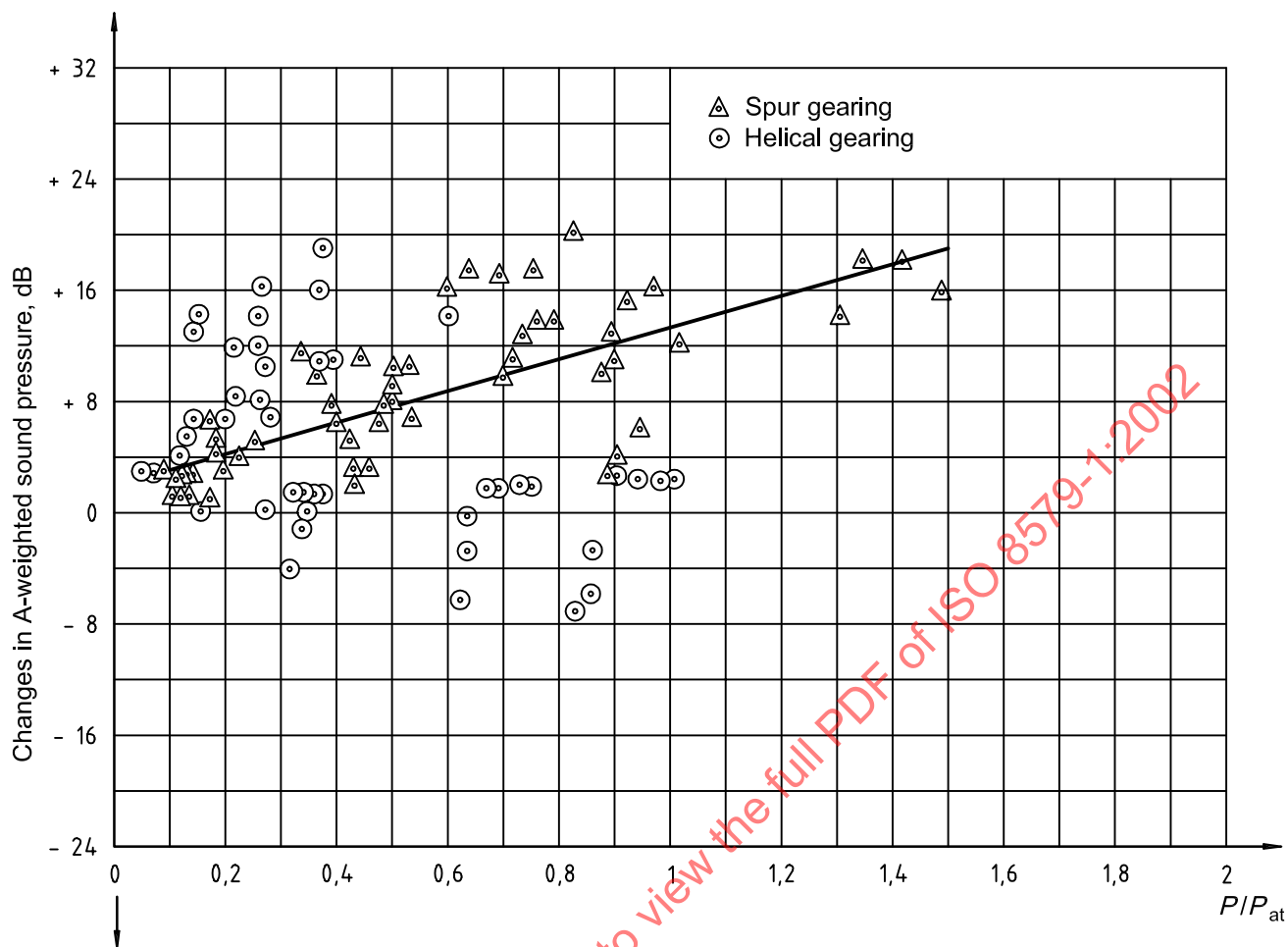


Helical gear units

$$\Delta L_{pA} = L_{pA, n} - L_{pA, n = 1750 \text{ r/min}}$$

- a Typical maximum
- b Average

Figure B.4 — Change in A-weighted sound pressure level (ΔL_{pA}) relative to that at 1 750 r/min versus input speed



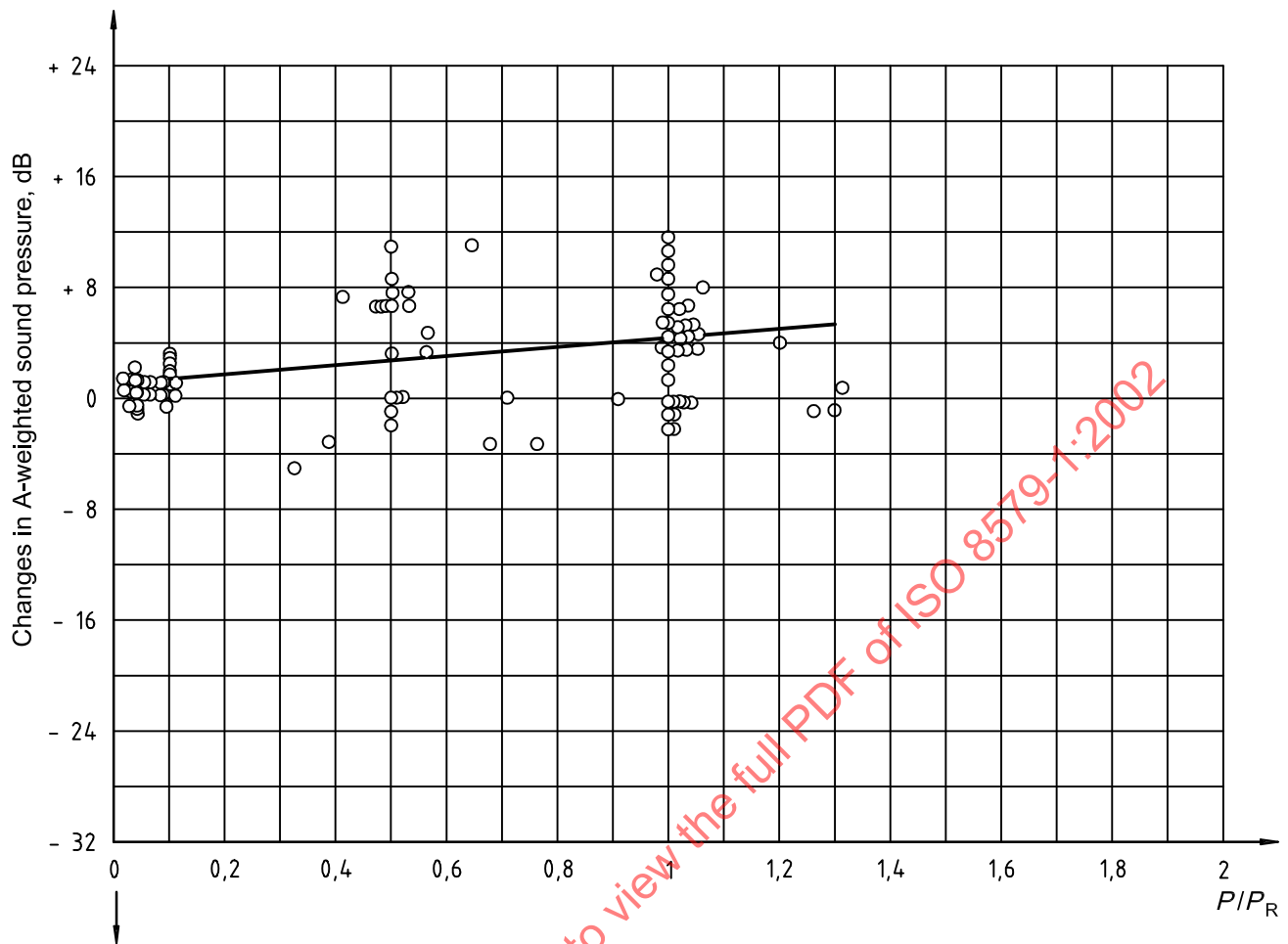
Published literature data

$$\Delta L_{pA} = L_{pA, n} - L_{pA, n=0}$$

P Transmitted power, in kilowatts

P_{at} AGMA strength rating, in kilowatts

Figure B.5 — Change in A-weighted sound pressure level relative to that at no load (ΔL_{pA}) versus P/P_{at}



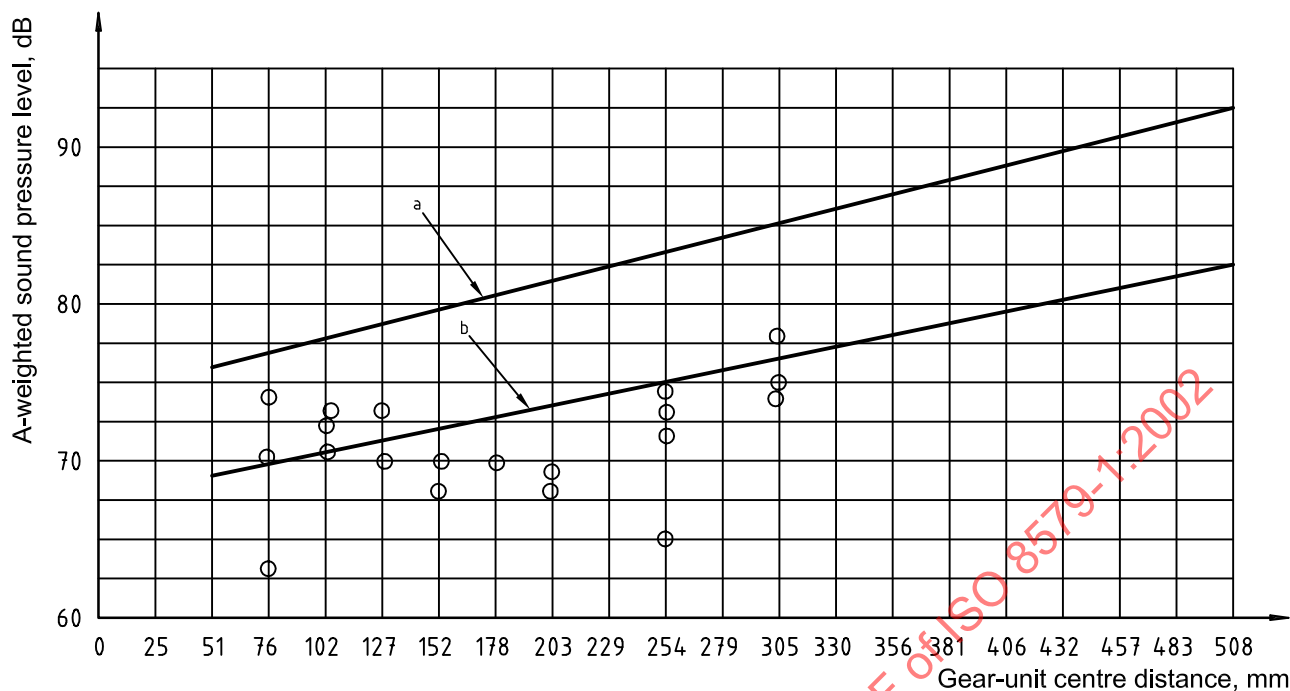
Manufacturer's data:
 helical, herringbone, spiral bevel and worm gear units

$$\Delta L_{pA} = L_{pA, n} - L_{pA, n=0}$$

P Transmitted power, in kilowatts

P_R Catalogue rating, in kilowatts

Figure B.6 — Change in A-weighted sound pressure level relative to that at no load (ΔL_{pA}) versus P/P_R



Single-reduction worm reducers at a input speed of 1750 r/min, fan cooled

- a Typical maximum
b Average

Figure B.7 — A-weighted sound pressure level versus centre distance, taken 1,5 m from housing, at no load or light load

B.3 Typical sound power levels

Sound power levels determined by acceptance testing from the operation of various gear configurations at varying levels of speed and load are shown in Figures B.8 to B.12.

B.4 Typical installed sound levels

Typical sound pressure levels obtained during the operation of an installed single-reduction, parallel shaft gear unit (1 m from the gear unit), containing gearing manufactured to quality grade 4 or lower, in accordance with ISO 1328-1 and at various levels of transmitted power, are shown in Figure B.13.

B.5 Typical sound intensity data

Sound power testing of installed gear units (up to 5 MW) evaluated using vectorial acoustic intensity techniques are shown in Figure B.14. This technique enables the rejection of extraneous sound and reverberation effects.

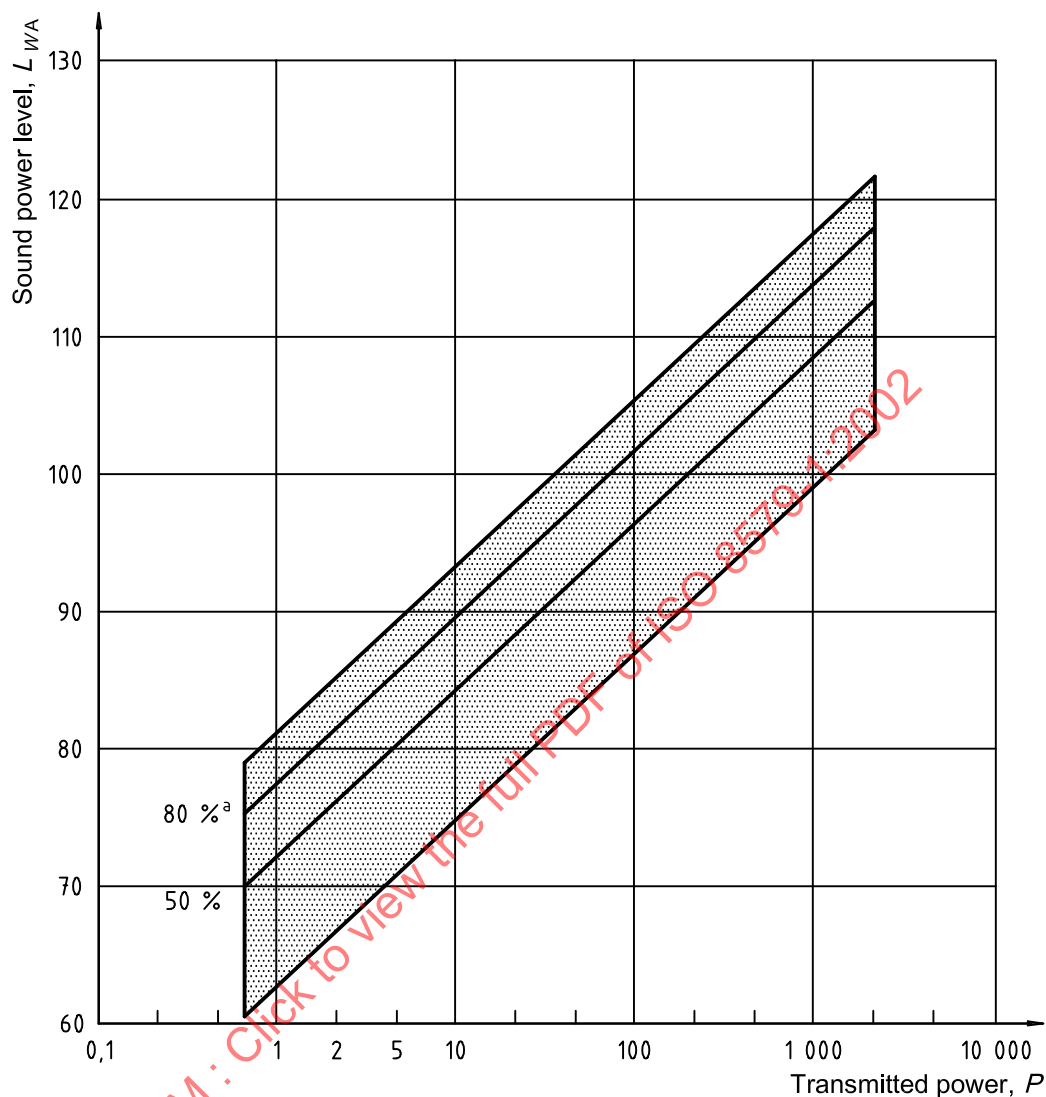
Logarithmic regression

$$L_{WA} = 77,1 + 12,3 \times \log P$$

(80 % line)

Variance $r^2 = 0,83$

Stated probability 90 %



a Regression line

Type: external cylindrical drives with the following predominant (> 80 %) characteristic properties.	
Housing:	Cast
Bearings:	Roller bearings
Lubrication:	Splash lubrication
Mountings:	Rigid on steel and/or concrete
Power	0,7 kW to 2 400 kW
Input speed (= max. r/min)	1 000 r/min to 5 000 r/min (majority 1 500 r/min)
Pitchline velocity	1 m/s to 20 m/s
Output torque	100 N·m to 200 000 N·m
Number of stages	1 to 3
Information on gear teeth	Highest speed stage helical gearing ($\beta = 10^\circ$ to 30°) hardened, finish cut. DIN 3960 quality 5 to quality 8.

Figure B.8 — Sound power values for cylindrical gears (industrial drives)

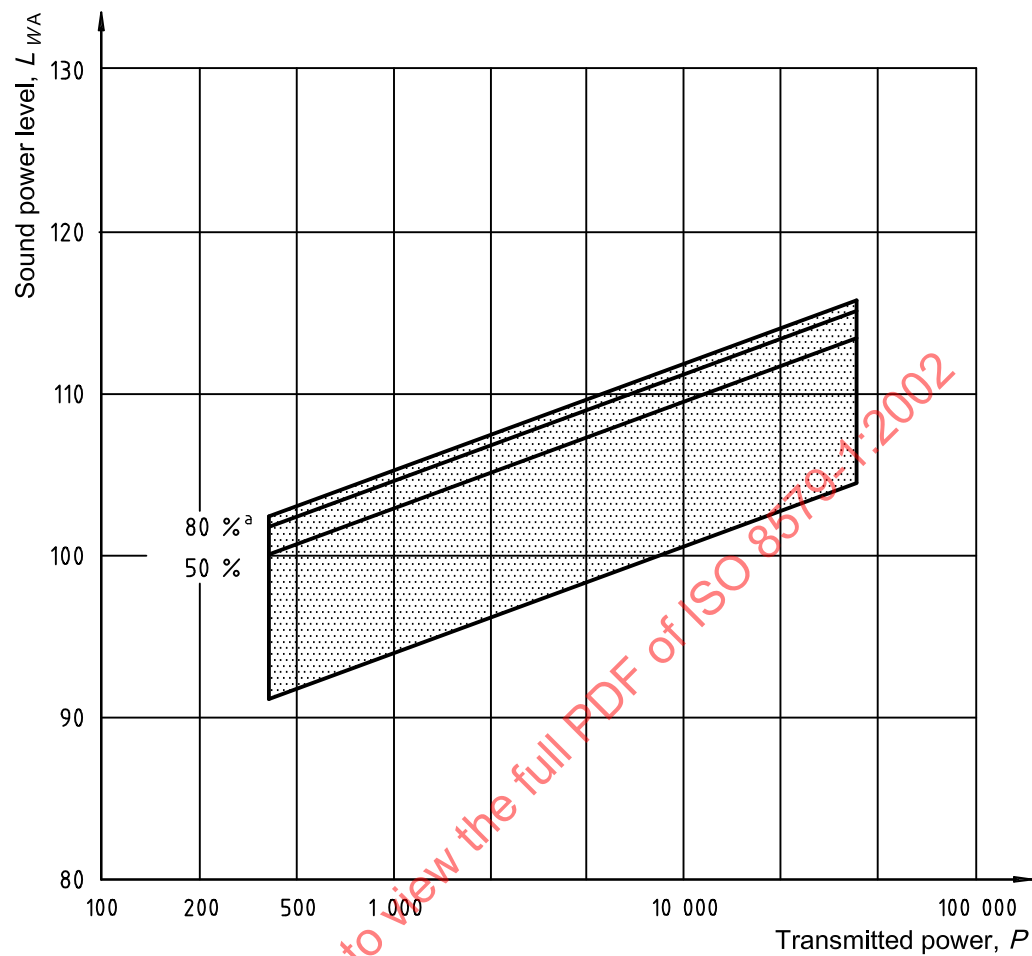
Logarithmic regression

$L_{WA} = 85,6 + 6,4 \times \log P$

(80 % line)

Variance $r^2 = 0,48$

Stated probability 90 %



a Regression line

Type: external cylindrical drives with the following predominant (> 80 %) characteristic properties.	
Housing:	Cast
Bearings:	Sleeve
Lubrication:	Pressure system with oil injection
Mountings:	Rigid on steel or concrete
Power	380 kW to 42 000 kW
Input speed (= max. r/min)	1 000 r/min to 12 700 r/min
Pitchline velocity	> 35 m/s
Output torque	3 600 N·m to 460 200 N·m
Number of stages	1 to 2
Information on gear teeth	Majority double helical ($\beta = 20^\circ$ to 30°) hardened, finish cut. DIN 3960 quality 3 to quality 5.

Figure B.9 — Sound power values for cylindrical gears (geared turbine drives)

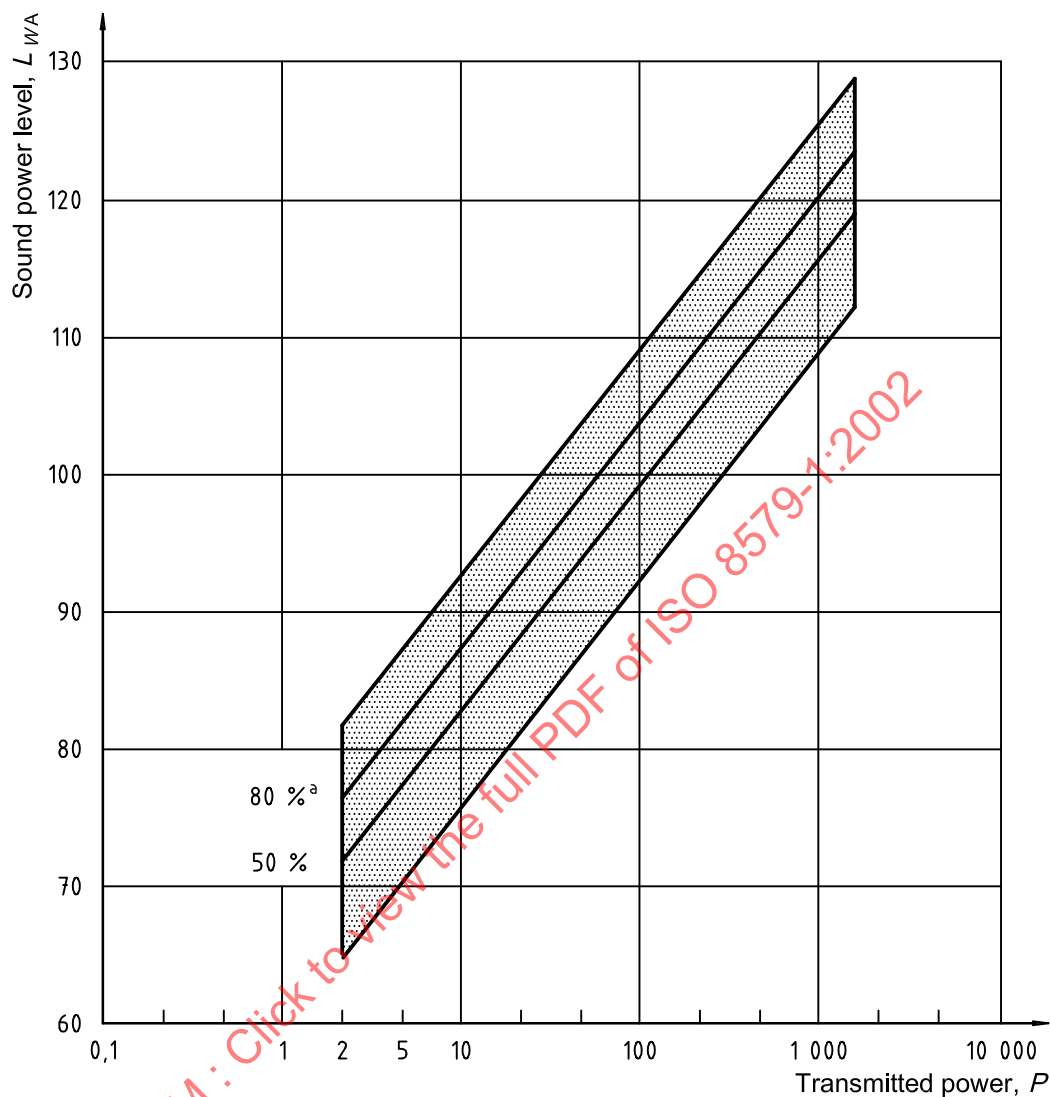
Logarithmic regression

$$L_{WA} = 77,1 + 15,9 \times \log P$$

(80 % line)

Variance $r^2 = 0,88$

Stated probability 90 %

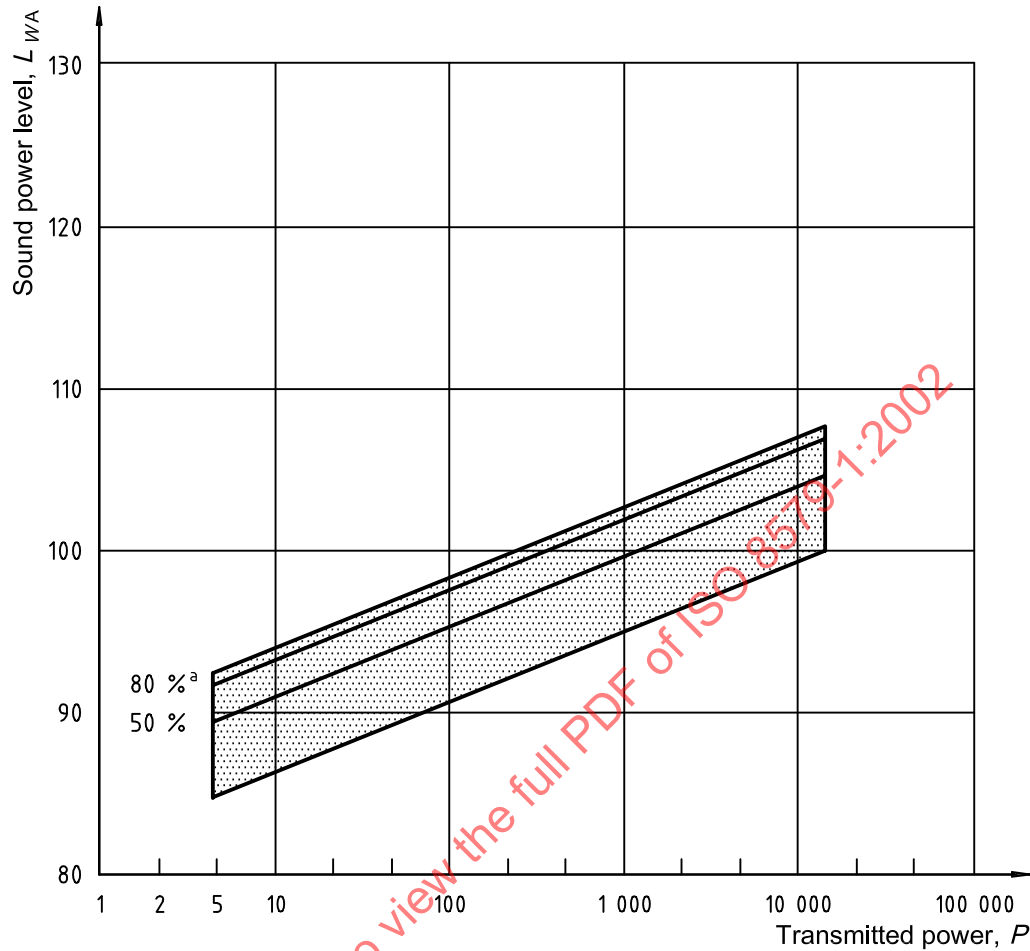


a Regression line

Type: bevel and bevel/cylindrical drives with the following predominant (> 80 %) characteristic properties.	
Housing:	Cast and welded construction
Bearings:	Roller bearings, bevel pinion tapered bore bearing
Lubrication:	Splash lubrication
Mountings:	Rigid on steel structure
Power	2 kW to 1 800 kW
Input speed (= max. r/min)	970 r/min to 3 000 r/min
Pitchline velocity	2 m/s to 24 m/s
Output torque	3 600 N·m to 190 000 N·m
Number of stages	1 to 3
Information on gear teeth	Bevel gear stage (mostly fastest stage) case-hardened and lapped; spiral bevel, no axis offset; fabrication and tooth measurement capabilities not as well developed as for cylindrical gears.

Figure B.10 — Sound power values for bevel and bevel/cylindrical gear drives

Logarithmic regression
 $L_{WA} = 87,7 + 4,4 \times \log P$
(80 % line)
Variance $r^2 = 0,78$
Stated probability 90 %



a Regression line

Type: planetary drives with the following predominant (> 80 %) characteristic properties.	
Housing:	Cast
Bearings:	Low-speed: roller bearings. High-speed: sleeve
Lubrication:	Injection
Mountings:	Rigid on steel and/or concrete
Power	6 kW to 12 500 kW
Input speed (= max r/min)	350 r/min to 16 500 r/min
Output torque	1 000 N·m to 330 000 N·m
Number of stages	1 to 2
Information on gear teeth	Spur gearing Helical gearing ($\beta = 25^\circ$ to 30°) Internal gear heat-treated, sun gear and planet gears hardened. The tooth quality increases with speed input.
Low-speed:	
High-speed:	

Figure B.11 — Sound power values for planetary drives

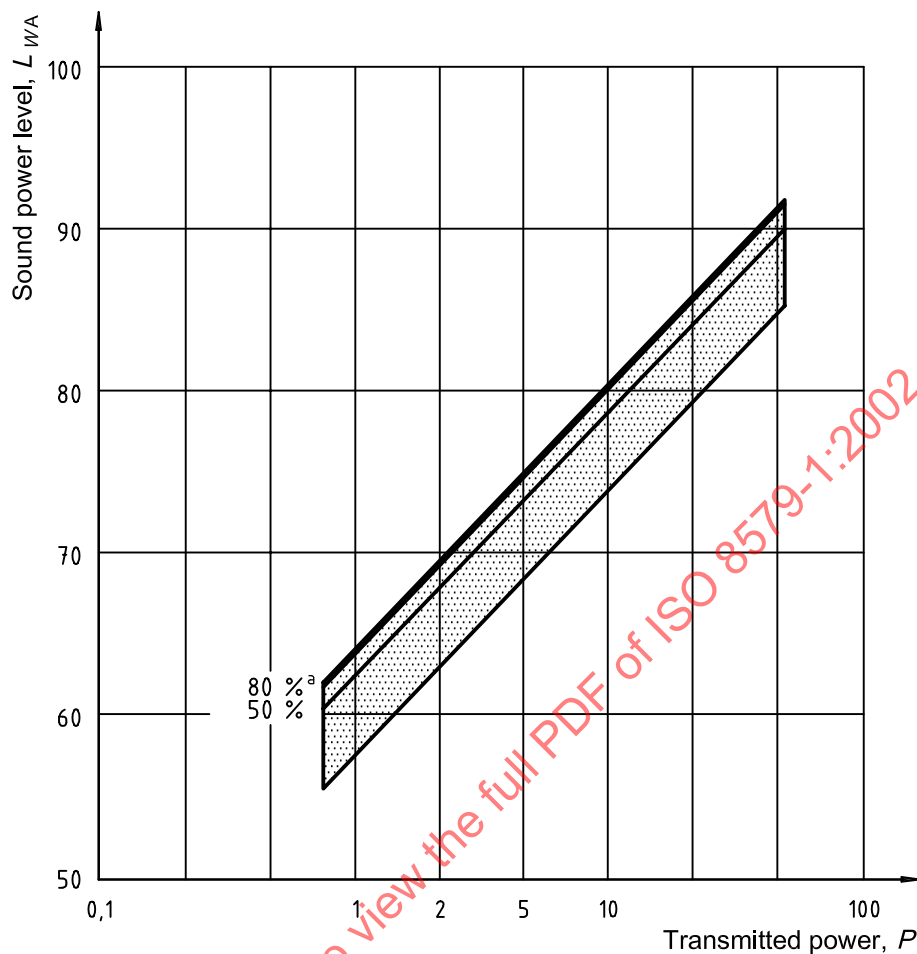
Logarithmic regression

$$L_{WA} = 65,0 + 15,9 \times \log P$$

(80 % line)

Variance $r^2 = 0,95$

Stated probability 90 %



^a Regression line

Type: Wormgear drives with the following predominant (> 80%) characteristic properties.	
Housing:	Strongly ribbed case housings (heat-dissipating)
Bearings:	Roller bearings
Lubrication:	Splash lubrication
Mountings:	Rigid on steel plates
Power	0,7 kW to 56 kW
Input speed (= max. r/min)	1 360 r/min to 1 480 r/min
Output torque	67 N·m to 3 800 N·m
Number of stages	1, simple wormgear drive
Worm starts	1 to 6 1 to 3
Information on gear teeth	Worm case-hardened and ground; wormgear of tin-bronze.

Figure B.12 — Sound power values for wormgear drives

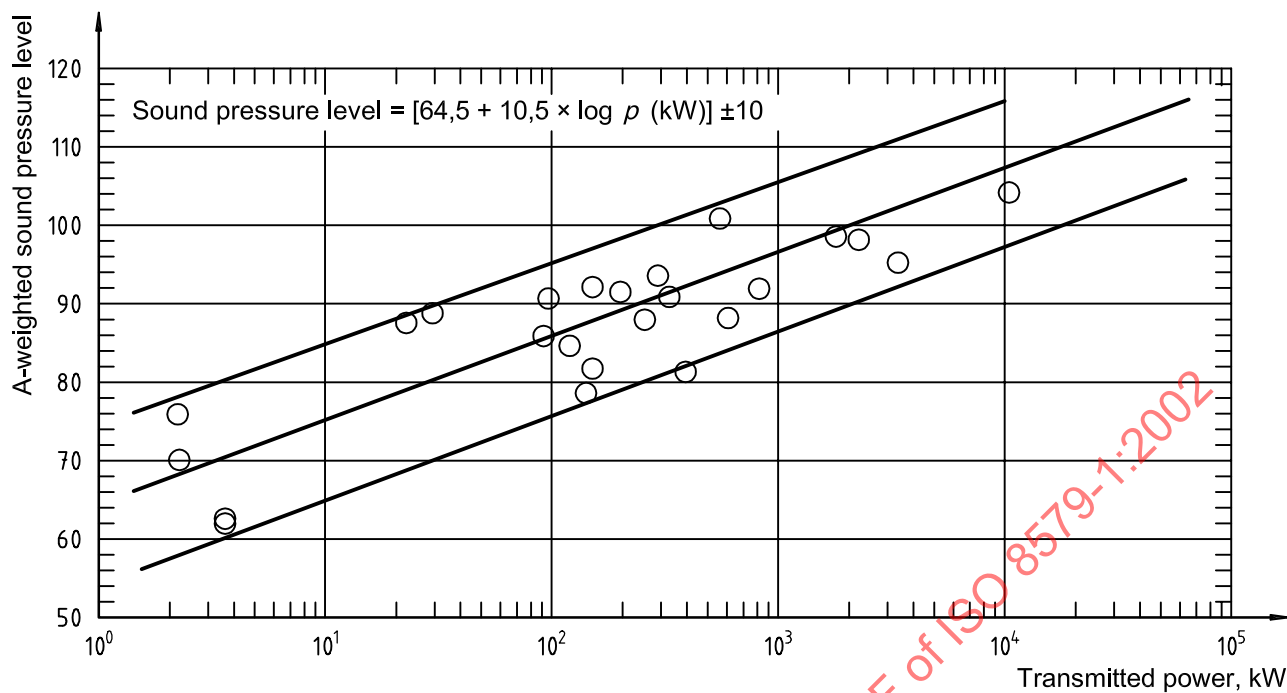


Figure B.13 — Typical A-weighted sound pressure level