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Liquid pumps and pump units — Noise test code — Grades 2 and 3 of accuracy

Pompes et groupes motopompes pour liquides — Code d'essai acoustique — Classes de précision 2 et 3

Reference number
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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

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

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

ISO 20361 was prepared by Technical Committee ISO/TC 115, *Pumps*.

This corrected version of ISO 20361:2007 incorporates the removal of “FDIS” from the footer on the cover page and from the header on succeeding pages.

Introduction

The noise emitted by a pump unit can be radiated by the casing of the pump, the driving system (e.g. motor, gear box, coupling), the piping system and all the connected structures.

On site, the perceived noise can be significantly increased by reverberation effects or by the radiation of extraneous sources.

Depending on the type of pump it may be useful to know

a) the noise of the pumping system (including piping);

b) the noise of the pump unit, including the driver and the transmission elements but excluding the noise of the piping system;

c) the noise emitted by the pump alone, excluding the noise from the driver, transmission elements and the pipings;

d) the noise emitted by each of those elements in respect to a given requirement or in view of an efficient sound proofing of the installation.

This International Standard describes methods for the determination of the noise emitted by a pump unit [case b)] or a pump alone [case c)]. Noise emission is expressed in terms of the sound power level of the machine and the emission sound pressure level at the relevant work station (see 6.2).

This International Standard is intended to enable the manufacturer to

— show the effectiveness of noise reduction,

— declare the noise emission levels.

This International Standard is a type C standard as stated in ISO 12100-1 and ISO 12100-2.

When provisions of this type C standard are different from those which are stated in A or B standards, the provisions of this type C standard take precedence.

The machinery concerned and the extent to which noise is covered are indicated in the scope of this International Standard.

Liquid pumps and pump units — Noise test code — Grades 2 and 3 of accuracy

1 Scope

This International Standard specifies all the information necessary to carry out efficiently and under standardized conditions the determination, declaration and verification of the airborne-noise emission of liquid pumps or pump units (see 4.1). It specifies the noise measurement methods and the operating and mounting conditions that shall be used for the test.

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

— declaring the noise emission values,

— purpose of noise control at source at the design stage.

NOTE 1 The determination of these quantities is also necessary for comparing the noise emitted by liquid pumps on the market.

The use of this International Standard ensures the reproducibility of the determination of the airborne noise-emission characteristics within specified limits determined by the grade of accuracy of the basic airborne noise measurement method used. Noise measurement methods according to this International Standard are engineering methods (grade 2) and survey methods (grade 3).

This International Standard does not deal with the characterization of the structure-borne sound and liquid-borne noise generated by liquid pumps.

NOTE 2 This International Standard is intended to complement EN 809, *Pumps and pump units for liquids — Common safety requirements*.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3743-1[1)], *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method 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[2)], *Acoustics — Determination of sound power levels of noise sources using sound pressure — Engineering method in an essentially free field over a reflecting plane*

1) To be published. (Revision of ISO 3743-1:1994)

2) To be published. (Revision of ISO 3744:1994)

ISO 3746[3)], *Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

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

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

ISO 9614-1, *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 the work station and at other specified positions from the sound power level*

ISO 12100-1, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic terminology, methodology*

ISO 12100-2, *Safety of machinery — Basic concepts, general principles for design — Part 2: Technical principles*

ISO 17769, *Liquid pumps — General terms and installation — Definitions, quantities, letter symbols and units*

3 Terms and definitions

For the purposes of this document, the definitions given in ISO 17769 and the following apply.

3.1
pump
equipment that is defined as being terminated by its inlet and outlet branches as well as in general its shaft ends

3.2
pump unit
equipment that is comprised of the pump as described in 3.1 and its driver (e.g. electric motor, steam turbine) including transmission elements (e.g. coupling, gear), baseplates and any auxiliary equipment supplied with the pump

4 Pump family and pump configuration

4.1 Pumps covered by this International Standard comprise liquid pumps of the rotodynamic and positive displacement, rotary and reciprocating types.

4.2 This International Standard provides two possibilities of measurement, either pump alone (see Table 1), or pump units (see Table 2). In these two cases, the pumps shall be installed

— on site (see 7.2.2), or

— on shop test stand (see 7.2.3), or

— in a specific facility intended for acoustic measurement (see 7.2.4).

3) To be published. (Revision of ISO 3746:1995)

4.3 Safety guards, e.g. coupling guards, insulation hoods etc., if any, shall be installed during noise-emission determination.

5 Sound power level determination

5.1 General

One of the following grade 2 of accuracy methods for determining the sound power level shall be used:

— ISO 3743-1 or ISO 3743-2;

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

NOTE 2 ISO 3743-2 is based upon special reverberation test room. This International Standard gives specifications to A-weighted sound pressure level measurement in order to calculate the sound power level.

— ISO 3744;

NOTE 3 ISO 3744 is based upon a non reverberant environment and low background noise. This International Standard specifies a method to calculate the sound power level from the measured A-weighted sound pressure levels or sound pressure levels in octave or third octave bands.

— ISO 9614-1 or ISO 9614-2.

If it has been shown that the applicability requirements of these grade 2 standards cannot be attained, e.g. too much background noise, then one of the following grade 3 methods shall be used:

— ISO 3746;

NOTE 4 ISO 3746 is less demanding, it only gives specifications to the measurement of A-weighted sound pressure levels and provides A-weighted sound power levels with grade 3 of accuracy.

— ISO 9614-1 or ISO 9614-2;

NOTE 5 ISO 9614 (all parts) can be used in all environments, including reverberation and extraneous noise sources to a large extent. This International Standard gives specifications to sound intensity and sound pressure measurement. Depending on the level of the reverberation and extraneous noise, it provides the sound power level either as A-weighted overall level or in octave or third-octave band. For grade 3 measurements, only the overall A-weighted sound power level is available.

NOTE 6 ISO 9614-1 requires measurements of sound intensity and simultaneously sound pressure level (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.

NOTE 7 ISO 9614-2 requires measurement of sound intensity and simultaneously sound pressure level by scanning. This can be made on partial or global surface depending on the configuration of the machine. The method generally reduces the measurement time.

— ISO/TR7849.

NOTE 8 ISO/TR 7849 is a technical report that can be used only when the prescriptions of the other methods are not fulfilled. This method is based upon measurement of vibration velocity of the relevant parts of the pump or pump unit. It provides an estimation of the A-weighted sound power level or sound power level in octave or third octave bands.

For selection of the basic International Standard for determination of the sound power level of a pump, Table 1 for pumps (pump alone) and Table 2 for pump units shall be used.

The reflecting plane shall be either a hard plane or a surface of water.

The International Standard, indicated in bold letters in Tables 1 and 2, describes the preferred method and shall be used where practical. If it is not practical, one of the other noted basic International Standards shall be used.

Table 1 — Pump (pump alone) **— Selection of International Standards for determination of sound power level**

Test arrangement	Grade	Pump power input P kW			
		$0{,}5 < P \leqslant 15$	$15 < P \leqslant 75$	$75 < P \leqslant 300$	$P > 300$
Specific facility[a]	2	**ISO 3744** ISO 3743-2 ISO 9614[b]	**ISO 9614**[b] ISO 3744 ISO 3743-2	**ISO 9614**[b] ISO 3744	**ISO 9614**[b] ISO 3744
Shop test stand	2	**ISO 9614**[b]			impractical
	3	**ISO 9614**[b] ISO 3746		**ISO 9614**[b]	
On site	2	**ISO 9614**[b]			impractical
	3	**ISO 9614**[b] ISO 3746		**ISO 9614**[b] ISO TR 7849	

[a] A facility can be qualified as specifically designed for noise measurements if it yields grade 2 measurements.

[b] ISO 9614 means ISO 9614-1 or ISO 9614-2.

Table 2 — Pump unit — Selection of standards for determination of sound power level

Test arrangement	Grade	Pump power input P kW			
		$0{,}5 < P \leqslant 15$	$15 < P \leqslant 75$	$75 < P \leqslant 300$	$0{,}5 < P \leqslant 15$
Specific facility[a]	2	**ISO 3744** ISO 3743-2 ISO 9614[b]		**ISO 3744** ISO 9614[b]	**ISO 9614**[b] ISO 3744
Shop test stand	2	**ISO 3744** ISO 3743-1[c] ISO 9614[b]	**ISO 3744** ISO 9614[b]	**ISO 9614**[b] ISO 3744	**ISO 9614**[b]
	3	**ISO 3746** ISO 9614[b]		**ISO 9614**[b] ISO 3746	**ISO 9614**[b] ISO 3746
On site	2	**ISO 9614**[b] ISO 3744			**ISO 9614**[b]
	3	**ISO 3746** ISO 9614[b]		**ISO 9614**[b] ISO 3746	

[a] A facility can be qualified as specifically designed for noise measurements if it yields grade 2 measurements.

[b] ISO 9614 means ISO 9614-1 or ISO 9614-2.

[c] ISO 3743-1 may be used for pump units in a shop test stand at the condition that pipings are properly lagged.

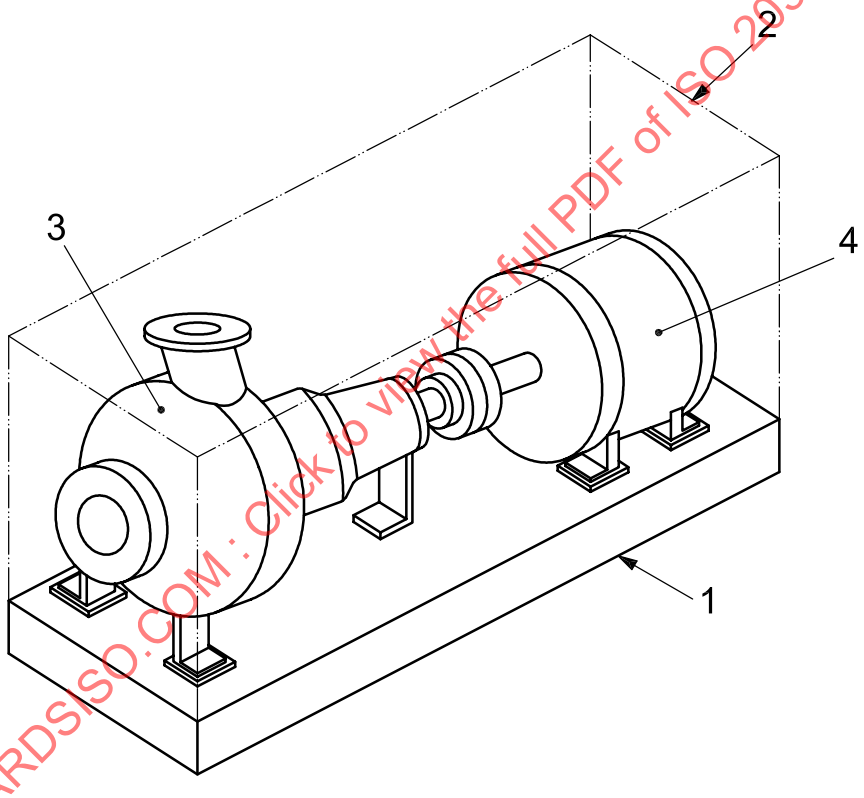
5.2 Specific considerations for reference box, measurement surface, position of microphones and intensity probe

5.2.1 General

When ISO 3744, ISO 3746 or ISO 9614 is used, 5.2.2 to 5.2.4 apply.

5.2.2 Reference box

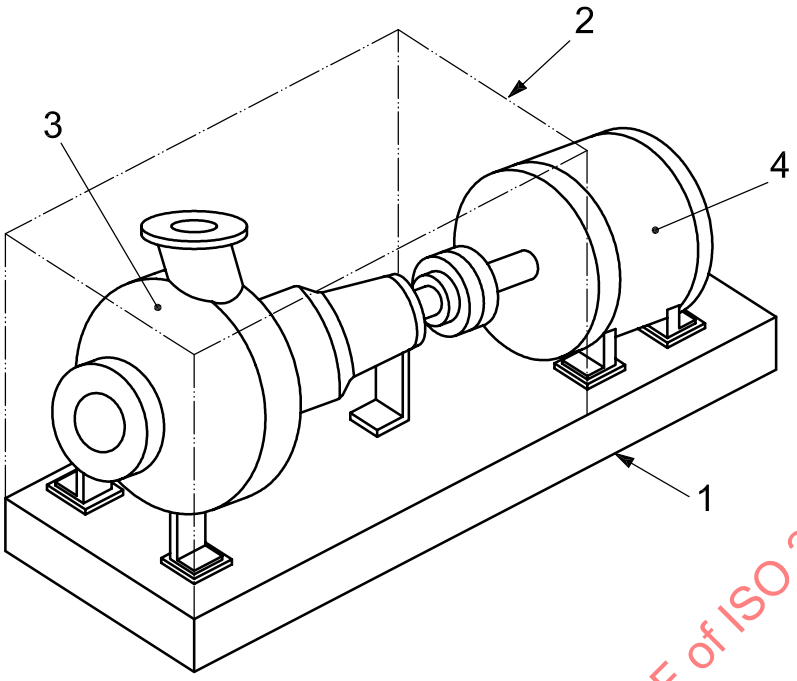
The reference box is an hypothetical surface, the smallest simple volume (parallelepiped, box, cylinder, etc.) containing the pump unit or pump and the flanges of the machine but excluding the pipings for the pump unit and pipings, transmission elements and driver for pumps (pump alone) and small individual components of the source that do not contribute to the sound radiation. For ISO 3744 and ISO 3746, the reference box is a parallelepiped. The box encloses the source and terminates on the reflecting plane (hard ground or water). For examples of reference boxes see Figures 1 and 2.



Key

1 reflecting plane
2 reference box
3 pump
4 driver

Figure 1 — Reference box for pump unit (example)



Key

1 reflecting plane
2 reference box
3 pump
4 driver

Figure 2 — Reference box for pump (alone) (example)

5.2.3 Measurement surface and microphone positions

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

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 and ISO 3746, both of which are based on sound pressure level measurements, the distance shall be chosen equal to 1 m.

  Where the background noise requirements of these International Standards are not met, a distance smaller than 1 m but larger than 0,25 m may be chosen.

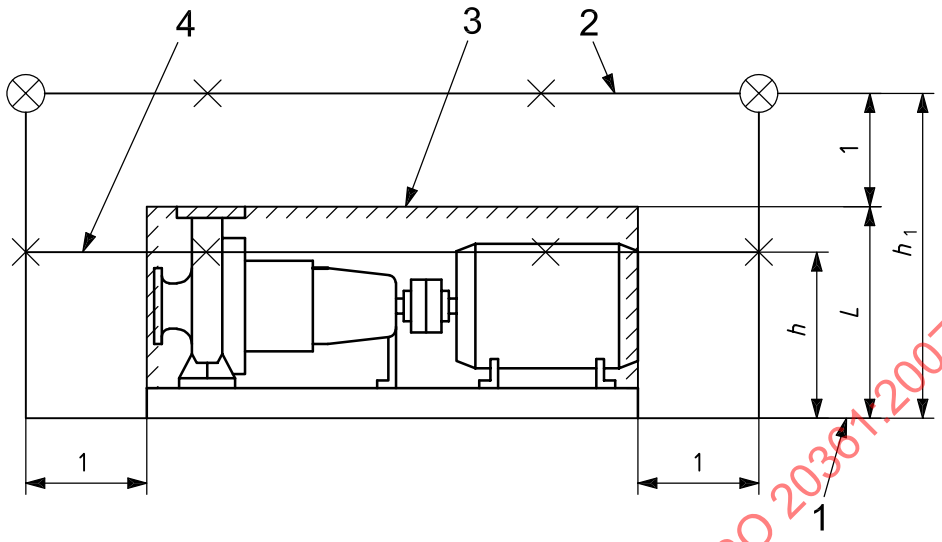
— For ISO 9614-1 and ISO 9614-2, both of which are based on a sound intensity measurement, the distance shall be

  — $d_1 \geqslant$ 0,5 m for ISO 9614-1;

  — 0,2 m $\leqslant d_2 \leqslant$ 0,5 m for ISO 9614-2.

For the measurement surface, see Figures 3 to 6 and Annex A.

Dimensions in metres



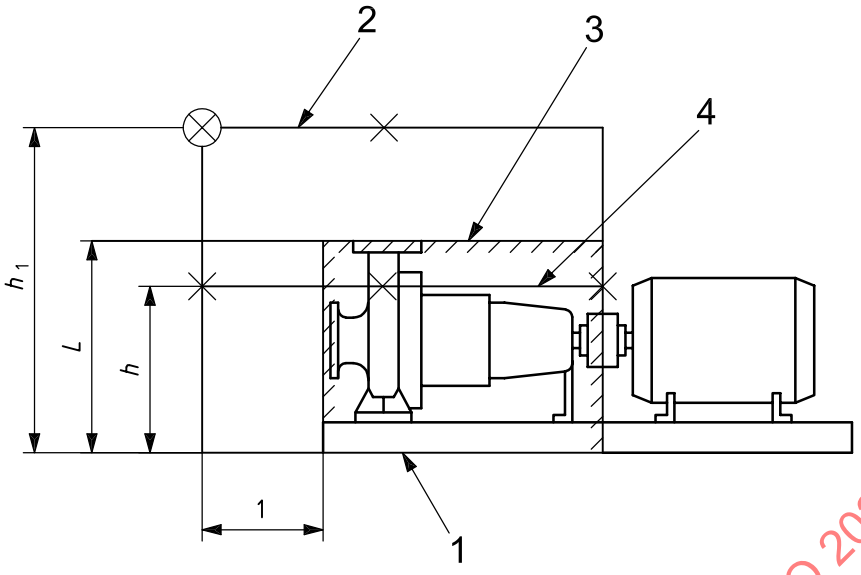
Key

1 reflecting plane
2 upper measurement surface
3 reference box
4 median measurement surface
× microphone positions for grade 3
⊗ additional microphone positions for grade 2
L height of the reference box, equal to the highest pump-unit point
h height, expressed in metres, of the median measurement plane: $h = (L + 1)/2$
h_1 height, expressed in metres, of the upper measurement plane: $h_1 = L + 1$

Figure 3 — Typical measurement surface and planes for sound pressure level measurement for a pump unit

In the case of the pump alone, Figure 4 indicates the position of the measurement surface. No microphone shall be placed on the face of this surface that looks at the motor (see also Annex A).

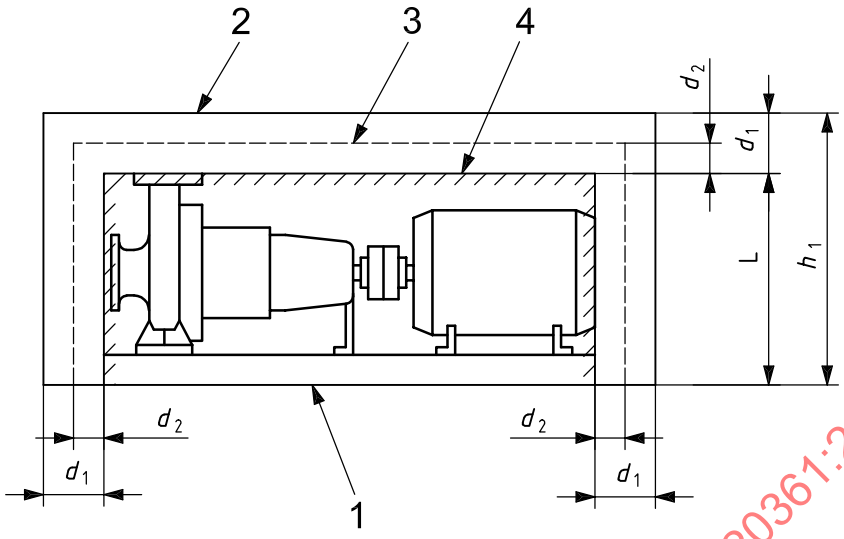
The practical microphone positions for different pump types and sizes are given in Annex B.



Key

1 reflecting plane
2 upper measurement surface
3 reference box
4 median measurement surface
× microphone positions for grade 3
⊗ additional microphone positions for grade 2
L height of the reference box, equal to the highest pump-unit point
h height, expressed in metres, of the median measurement plane: $h = (L + 1)/2$
h_1 height, expressed in metres, of the upper measurement plane: $h_1 = L + 1$

Figure 4 — Typical measurement surfaces and planes for sound pressure level measurement for pump alone

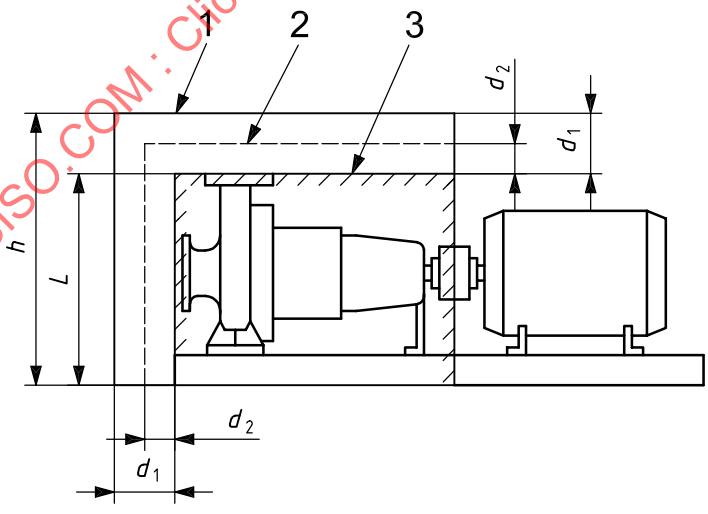


Key

1 reflecting plane
2 measurement surface for fixed points
3 closer measurement surface for scanning
4 reference box

$d_1 \geqslant 0{,}5$ m
$h_1 = L + d_1$
$d_2 = 0{,}2$ m to $0{,}5$ m

Figure 5 — Typical measurement surfaces and planes for sound intensity measurement for pump unit



Key

1 measurement surface for fixed points
2 closer measurement surface for scanning
3 reference box

$d_1 \geqslant 0{,}5$ m
$h_1 = L + d_1$
$d_2 = 0{,}2$ m to $0{,}5$ m

Figure 6 — Typical measurement surface for sound intensity measurement for pump alone

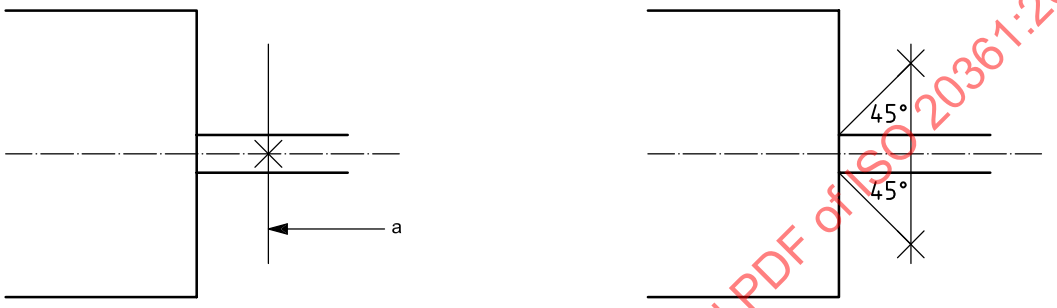
5.2.4 Position of microphones and intensity probes

The position of the microphones or intensity probes on the measurement surface shall be those specified by the basic measurement standard used. For typical microphone positions see Figures 3 to 6 and Annex B. However, if necessary, one or several of these positions shall be altered in order to fulfil the following requirements.

— The distance between a microphone and the surface of a pipe shall not be smaller than 0,5 m.

— The distance between the intensity probe and the surface of a pipe shall not be smaller than 0,2 m.

If a microphone position falls on the axis of a piping or centreline of the shaft, this point shall not be measured. It shall be replaced by two points located at 45° to the axis as shown in Figure 7.



a) Incorrect arrangement **b) Correct arrangement**

Key

× microphone positions for measurements

[a] No measurement shall be made at this point.

Figure 7 — Special arrangement of microphone positions

6 Emission sound pressure level determination

6.1 Basic standard to be used

The A-weighted emission sound pressure level at the work station (see 6.2) shall be determined using ISO 11203:1995 (method with 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 surface enveloping the pump defined in 6.2.

6.2 Relevant work station

Since liquid pumps have no identifiable work stations, the work station is defined conventionally as being the box-shaped surface enveloping the pump at a distance of 1 m from the reference box defined in ISO 3744.

6.3 Measurement uncertainty

The measurement uncertainty is that of the relevant standard used for the determination of the sound power level.

7 Installation and mounting conditions

7.1 General

Installation and mounting conditions are also dependent of the grade of accuracy required. For a required grade of accuracy, sound intensity measurements are much less demanding than sound pressure measurements since sound intensity strongly eliminates the effect of extraneous sources such as pipes and valves.

7.2 Noise test situation

7.2.1 General

Noise test situations shall be as follows:

— on-site, or

— on shop test stand, or

— specific facility intended for acoustic measurement.

Tests conducted on shop test stand, except for small powers machines using anechoic chambers, are done only for indication and shall not be considered for contractual limits, since such stands are heavily reverberating and measures are depending upon surrounding tested machines.

7.2.2 Test on site

The following actions for improving the acoustic environment shall be taken into account (see 9.2):

— temporary acoustic lagging of piping;

— operating at the minimum of other noise sources;

— temporary screening of the driver and transmission elements for measurement on pumps (pump alone);

— temporary application of absorbing material on reverberating surfaces.

7.2.3 Test on shop test stand

Acoustic feed-back from the throttling device in the outlet piping and the connected auxiliary piping and system shall not influence the measurement of the noise emission of the pump.

Low noise throttling devices should preferably be used.

The following shall be taken into account:

— acoustic lagging of connected pipings;

— operating at the minimum of other noise sources;

— temporary screening of the driver and transmission elements for measurements on the pump alone;

— temporary application of absorbing material on reflecting surfaces;

— use of anti-vibration techniques.

7.2.4 Test on a specific facility intended for acoustic measurement

The test facility shall fulfil the following minimum requirements:

— use of low-noise throttling devices;

— reduction of the effects of standing-waves effects in the inlet and outlet piping (for example, by using anechoic liquid terminations);

— acoustic lagging of inlet and outlet piping;

— insulation of structure-borne noise between pump (pump alone)/pump unit and supporting elements;

— reduction of mechanical resonances;

— insulation of driver and transmission elements in an acoustic enclosure in case of pump alone measurement;

— avoidance of air in the pumped liquid, e.g. by using a close loop.

8 Operating conditions during noise measurement

8.1 General

The measurement shall be made while the liquid pump or pump unit operates with the pumped liquid as given in 8.2 and at a point within the range of intended use as specified in the operating manual. This operating point is defined

— as the point of best efficiency within rated conditions,

— for mass product pumps, as the maximum product $Q \cdot H$ is maximum.

NOTE Other operating points can be given in the contractual specifications.

Where the power of the test bed facility is limited, the noise measurement shall be made at reduced conditions, calculated on the basis of converting laws.

8.2 Pumped liquid

The pumped liquid shall be in accordance with the liquid used for the hydraulic performance test.

8.3 NPSHA value

During the noise measurement the pump shall operate with NPSH-values at rated conditions: NPSHA greater than NPSHR and NPIPA greater than NPIPR.

NOTE The cavitation noise can significantly increase the emitted noise level.

9 Information to be recorded

9.1 General

The information to be recorded includes all the information required by the noise measurement standard used for the test.

Any deviation from this International Standard and/or from the noise measurement standard used shall be recorded together with the technical reasons for such deviations.

9.2 Test report

The information included in the test report shall be at least the information the manufacturer requires to prepare a noise-emission declaration.

The minimum information shall be the following:

a) full identification of the pump or pump unit;

b) technical characteristics of the pump or pump unit;

c) reference to this noise test code and to the basic noise emission standard that has been used among those allowed by this noise test code;

d) statement that all requirements of this noise test code and of the basic standard used have been fulfilled; if this is not the case, deviations shall be reported together with the technical reasons for those necessary deviations;

e) description of the installation, mounting and operating conditions used including the choices made according to 7.2. For measurements on site a photo report of the installation/environment;

f) noise-emission values obtained: A-weighted sound power level, A-weighted emission sound pressure level and, when possible, frequency-band sound power level shall be reported.

NOTE This test report may also include contractual information.

10 Declaration and verification of noise emission values

The declaration and verification of the noise emission values shall be in accordance with ISO 4871.

The manufacturer shall declare both the A-weighted sound power level and the A-weighted emission sound pressure level at the relevant work station defined in 6.2 of this International Standard. The noise declaration shall mention explicitly the fact that the noise emission values have been obtained in accordance with this noise test code and indicate which basic standard for the determination of the sound power level has been used. The noise declaration shall indicate clearly the deviation from this noise test code and/or from the basic standards used, if any.

The declaration of the noise emission values shall be presented as a dual-number noise emission declaration in accordance ISO 4871. It shall declare both the noise emission values L ($L_{p\mathrm{A}}$ and $L_{W\mathrm{A}}$) and the respective uncertainty, K ($K_{p\mathrm{A}}$ and $K_{W\mathrm{A}}$).

The following values of K shall be taken as a basis:

— for grade 2: $K = K_{W\mathrm{A}} = K_{p\mathrm{A}} = 2{,}5$ dB

— for grade 3: $K = K_{W\mathrm{A}} = K_{p\mathrm{A}} = 4$ dB

Verification shall be conducted by using the same mounting and operating conditions as those used for the initial determination of noise emission values. It shall be made on one machine in accordance with ISO 4871:1996, 6.2.

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

Annex A
(normative)

Pump alone — Measurement surface

A.1 Sound pressure measurement on a measurement surface

As indicated in 5.2.3 (text before Figure 4), no measurement shall be carried out on the face of the measurement surface looking at the driver. This is justified because the sound pressure levels on this face are contaminated by the sound of the driver.

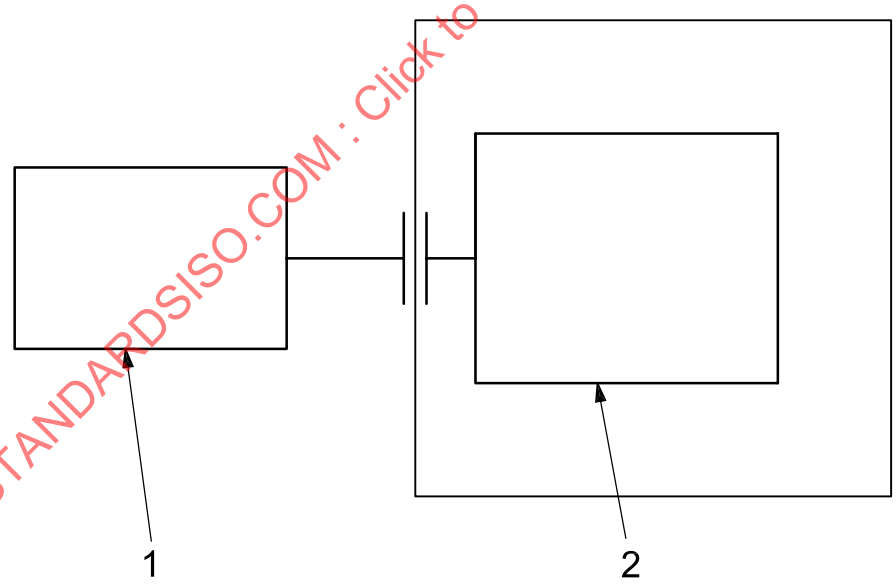
For the calculation of the sound power level, the surface, S, to consider is the measurement surface minus the surface of the face where no measurement is carried out.

A.2 Sound intensity measurement

The measurement distance is that specified in 5.2.3. However, regarding measurements to be done between the pump and the driver.

— The measurement surface shall go through the centre of the coupling device, as shown in Figure A.1.

— If the available space does not allow to fulfil the measurement distance specification of 5.2.3, a shorter distance shall be chosen.



Key

1 driver

2 pump

Figure A.1 — Typical position of measurement surface for sound intensity measurements

Annex B
(normative)

Pump units — Microphone positions for sound pressure level measurement on the measurement surface for different pump types and sizes

B.1 General

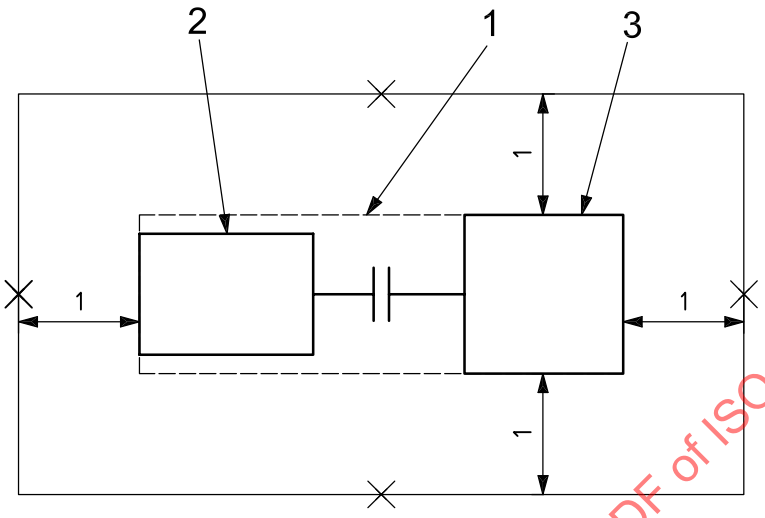
The microphone positions specified in this annex are not exactly those prescribed by the basic International Standards ISO 3744 and ISO 3746.

NOTE The machine being constituted of two separate machines (the driver and the pump), it is preferable to centre the measurement points on these component machines.

B.2 Horizontal pump units

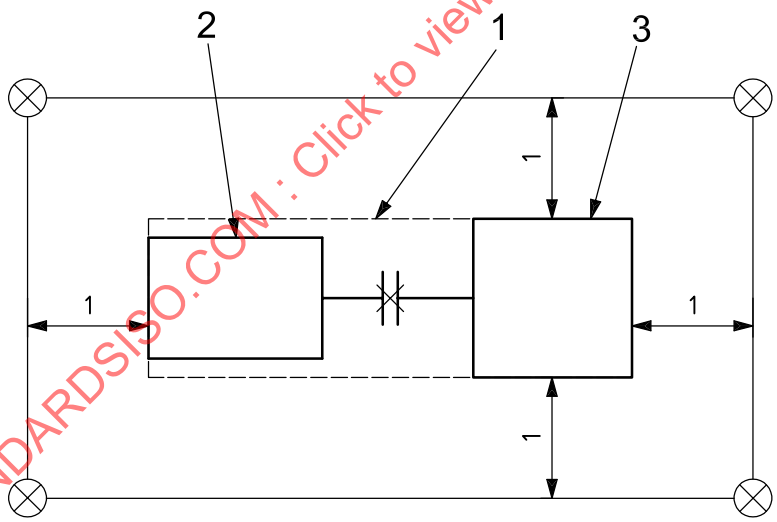
B.2.1 Horizontal pump units with overall dimensions smaller than 1 m

Dimensions in metres



× microphone positions for grade 3

a) Median measurement surface



× and ⊗ microphone positions for grade 2

b) Upper measurement surface

Key

1 reference parallelepiped
2 driver
3 pump

Figure B.1 — Microphone positions (unscaled)