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Safety of machinery — Laser processing machines —

Part 3: Noise reduction and noise measurement methods for laser processing machines and hand-held processing devices and associated auxiliary equipment (accuracy grade 2)

Sécurité des machines — Machines à laser —

Partie 3: Méthodes de mesure et de réduction du bruit des machines à laser, des dispositifs de traitement portatifs et des équipements auxiliaires connexes (classe de précision 2)

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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/IEC 11553-3 was prepared by Technical Committee ISO/TC 172, *Optics and photonics*, Subcommittee SC 9, *Electro-optical systems*, in collaboration with IEC/TC 76, *Optical radiation safety and laser equipment*.

ISO/IEC 11553 consists of the following parts, under the general title *Safety of machinery — Laser processing machines*:

— *Part 1: General safety requirements*

— *Part 2: Safety requirements for hand-held laser processing devices*

— *Part 3: Noise reduction and noise measurement methods for laser processing machines and hand-held processing devices and associated auxiliary equipment (accuracy grade 2)*

Introduction

The Machinery Safety Directive issued by the Council of the EU outlines essential and mandatory requirements that must be met in order to ensure that machinery is safe. In response, CEN/CENELEC initiated a programme to produce safety standards for machines and their applications. This part of ISO/IEC 11553 is one in that series. It has been prepared as a harmonized standard to provide a means of conforming with the essential safety requirements of the Machinery Directive and associated EFTA Regulations.

This document is a type B standard as stated in ISO 12100. The provision of this document may be supplemented or modified by a type C standard.

For machines which are covered by the scope of a type C standard and which have been designed and built according to the provision of that standard, the provisions of that type C standard take precedence over the provisions of this type B standard.

It is applicable to machines using laser radiation to process materials. The purpose of this part of ISO/IEC 11553 is to prevent injuries to persons by

— listing potential hazards generated by machines containing lasers,

— specifying safety measures and verifications necessary for reducing the risk caused by specific hazardous conditions,

— providing references to pertinent standards, and

— specifying the information which is to be supplied to the users so that they can establish proper procedures and precautions.

Safety of machinery — Laser processing machines —

Part 3: Noise reduction and noise measurement methods for laser processing machines and hand-held processing devices and associated auxiliary equipment (accuracy grade 2)

1 Scope

This part of ISO/IEC 11553 describes the requirements to deal with noise hazards and specifies all the information necessary to carry out efficiently and under standardized conditions the determination, declaration and verification of airborne noise emission from laser processing machines and hand-held laser processing devices within the scope of ISO/IEC 11553-1 and ISO/IEC 11553-2. It specifies the safety requirements relating to noise hazards. It specifies noise measurement methods, installation and operating conditions to be used for the test, together with the information to be supplied by manufacturers of such equipment.

This part of ISO/IEC 11553 applies to those laser processing machines and hand-held laser processing devices included in the scope of ISO/IEC 11553-1 and ISO/IEC 11553-2.

Noise emission characteristics include emission sound pressure levels at work stations and the sound power level. Declared noise emission values permit comparison of laser processing machines and hand-held laser processing devices on the market.

The use of this noise test code (see Annex A) ensures the reproducibility of the determination of the characteristic noise emission values within specific limits. These limits are determined by the accuracy grade of the noise emission measuring method used. Noise emission measurements specified by this part of ISO/IEC 11553 meet the requirements of an engineering method (accuracy grade 2).

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

ISO 3746, *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, *Acoustics — Declaration and verification of noise emission values of machinery and equipment*

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

ISO 11201, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions in an essentially free field over a reflecting plane with negligible environmental corrections*

ISO 11202, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections*

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*

ISO 11204, *Acoustics — Noise emitted by machinery and equipment — Determination of emission sound pressure levels at a work station and at other specified positions applying accurate environmental corrections*

ISO/IEC 11553-1, *Safety of machinery — Laser processing machines — Part 1: General safety requirements*

ISO/IEC 11553-2, *Safety of machinery — Laser processing machines — Part 2: Safety requirements for hand-held laser processing devices*

ISO 12100:2010, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

IEC 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

EN 352-1, *Hearing protectors — General requirements — Part 1: Ear-Muffs*

3 Noise hazards

Noise generated by laser processing machines and hand-held laser processing devices can result in, for example:

a) permanent hearing loss;

b) tinnitus;

c) tiredness, stress, headaches;

d) other effects such as loss of balance, loss of awareness;

e) interference with speech communication;

f) inability to hear acoustic warning signals.

4 Safety requirements and measures

4.1 General requirements for noise reduction

Noise reduction shall be an integral part of the design process by specifically taking into account the measures at source as suggested in ISO/TR 11688-1. The success of the applied noise reduction measures is assessed on the basis of the actual noise emission values according to the noise test code specified within this part of ISO/IEC 11553 in relation to other laser processing machines of a similar application.

4.2 Noise reduction measures

Appropriate noise reduction measures shall be applied.

Particular considerations can be given to:

a) selecting low noise level pumps rather than enclosing the pumps;

b) releasing of pneumatic energy (To conserve energy, unnecessary releases should be avoided. Silencers or exhaust filters should be considered.);

c) stabilizing vibrating pipelines by special fastenings to reduce noise created by such movements;

d) the laser power generation noise source by selection of low noise components such as fans or by resilient mounting or absorber;

e) damping measures to be applied at the cooling and fume exhaust systems;

f) preventing vibration of panels by fitting stiffening strips or noise attenuating materials to reduce the radiation of noise;

g) placing noise producing component parts away from the operator position whenever practicable;

h) applying full and partial acoustic enclosures inside the guard enclosing the process zone to limit the radiation of noise generated by the laser process into the environment.

The above list is not exhaustive. Alternative technical measures (that may have identical or improved efficiency) for noise reduction can be considered.

5 Verification of safety requirements for noise emission reduction and/or protection measures

Noise emission values shall be measured by utilizing appropriate measurement method(s) and a noise emission declaration shall be given in the instructions for the user if the emission sound pressure level measured is higher than 70 dB.

An initial test can be made in order to check whether the more expensive measurement procedure described in this standard is necessary or not. The initial test is based on the application of less expensive class 2 sound pressure level meters according to IEC 61672-1. The operating conditions are as described in Clause A.9. Any environmental correction or background noise correction is not applied.

In the case that the A-weighted sound pressure level at the workstation, determined under the prescribed conditions, is not exceeding 65 dB(A) no further measurements following the procedures in this standard of ISO/IEC 11553 is required. The noise emission declaration shall simply state: Emission sound pressure level $L_{pA} \leq 70$ dB.

If the emission sound pressure level measured is greater than 65 dB, the noise reduction measures, measurements, verification and documentation outlined in this part of ISO/IEC 11553 are necessary.

Table 1 summarizes verification methods of safety requirements for noise emission reduction and/or protective measures.

Table 1 — Verification method of safety requirements for noise emission reduction and/or protective measures

Clause	Verification method
4	Measurement of noise emission values according to the noise test code shown in Annex A.
6	Verification that a noise emission declaration is given in the instructions.

6 Information for the user

The information for the user shall contain the following information on airborne noise emissions, determined and declared in accordance with Annex A:

a) the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this level does not exceed 70 dB(A), this fact shall be indicated;

b) the peak C-weighted instantaneous sound pressure value at workstations, where this exceeds 63 Pa (130 dB in relation to 20 µPa);

c) the A-weighted sound power level emitted by the machinery, where the A-weighted emission sound pressure level at workstations exceeds 80 dB(A).

Additionally if further protection is necessary, the information shall:

d) recommend possible noise enclosures, screens to be fitted to the machinery, etc.;

e) recommend additional noise reduction measures, for example, to use sound proofing cabins, as well as necessary requirements relating to installation and assembly for reducing noise;

f) recommend the use of low-noise operating modes or limited time of operation;

g) recommend the wearing of personal hearing protectors (see EN 352-1).

Annex A
(normative)

Noise test code (accuracy grade 2)

A.1 Emission sound pressure level determination

The measurement positions for determining the A-weighted emission sound pressure level at work stations and other positions are specified in Clause A.9. All microphone positions are at a height of 1,55 ± 0,075 m above the floor or access level.

A-weighted emission sound pressure levels shall be determined in accordance with preferably ISO 11201 grade 2, or ISO 11202 grade 2 or ISO 11204 grade 2. If the environmental conditions make it impossible to reach an accuracy grade 2, ISO 11202 grade 3 or ISO 11204 grade 3 shall be applied. The test report shall state the reasons why it was not possible to apply a grade 2 method.

NOTE The advantage of applying ISO 11201 grade 2 is that for $K_2 \leq 2$ dB the environmental correction is not considered.

Emission sound pressure levels of laser processing machines with defined operator positions shall be measured as described in A.9.1.

For hand-held laser processing devices (HLDs) without remote component parts (power device, chiller, filter fan), the A-weighted emission sound pressure level shall be measured in accordance with A.9.3 Table A.5 I.

For hand-held laser processing devices (HLDs) with remote (several metres away) component parts, measurements shall be carried out separately for each machine part. The hand-held tool shall be measured according to A.9.3 Table A.5 I. and the remote component part according to A.9.3 Table A.5 II.

In those cases where the determination of the sound power level is required for HLDs, the use of ISO 11203 is permissible. However, it is necessary to distinguish between the hand-held laser tool and the remote component part. For the hand-held tool, the emission sound pressure level can be determined from the sound power level according to ISO 11203 with Q = 11 dB. If the associated component part also generates noise to such extent that the sound power level has to be declared, the emission sound pressure level can be determined by applying ISO 11203:1995, 6.2.3 d) with the measurement surface at a distance of about 1 m from the reference box according to ISO 3744.

A.2 Sound power level determination

A.2.1 General method

The A-weighted sound power levels shall be determined in accordance with ISO 3744 or ISO 9614-2 grade 2. If, due to inappropriate environmental conditions, these standards are not applicable ISO 3746 or ISO 9614-2 grade 3 shall be used. The test report shall state the reasons why it was not possible to apply an accuracy grade 2 method for determining the sound power level.

For hand-held laser processing devices with remote component parts, the hand-held tool and the remote component part shall be treated independently. The determination of the sound power level of the hand-held tool shall be done by defining the reference box around the test-setup described in A.9.3 Table A.5 II, see also Figure A.1. The measurement distance d of the parallelepiped measurement surface shall be 1 m. The operator shall position himself in such a way that he is not hinder the direct sound propagation from the tool to any measurement microphone.

For determining the sound power level of the component part, a parallelepiped measurement surface shall be applied.

A.2.2 Alternative method for large laser processing machines

For large laser processing machines, it is permissible to determine and declare instead of the A-weighted sound power level A-weighted emission sound pressure levels at specified measurement points around the machine.

The measurement positions are specified along a path around the machine at a height of 1,55 m ± 0,075 m above the floor or access level and at a distance of 1 m from the reference box according to ISO 3744. They shall be spaced so that the difference in A-weighted emission sound pressure levels between adjacent points does not exceed 5 dB. At least at one position on each side of the machine emission sound pressure levels shall be determined. This also applies if the machine is radiating sound rather uniformly. The maximum value shall be used for declaration. The measurement position of the emission sound pressure level used for declaration shall be recorded and reported.

NOTE Some complex custom made machines (e.g. combined with handling systems and integrated in complex production lines) are for the first time assembled and operated at the customers premises. In such a case, the noise emission values can only be measured there.

Examples for large laser processing machines are large flat-bed laser machines or robotic laser machines.

A.3 Assembly and installation conditions

The laser processing machine or hand-held laser processing device shall be assembled and installed in accordance with the manufacturer's instructions. If the conditions of installation are not known or if several modes of installation are possible, the type of installation used for the measurement of the noise emission values shall be specified in the test report.

The laser processing machines normally placed on a floor shall be placed for the measurement on a flat reflective floor. Hand-held tools shall be held by an operator as described in A.9.3 Table A.5 I. The associated component parts (e.g. laser system, power device, chiller) shall be placed on a reflective floor.

The assembly and installation conditions of the machine shall be identical for determining both sound power levels and also emission sound pressure levels.

Care shall be taken that any electrical connections, piping or air ducts connected to the machine do not significantly increase noise emission.

A.4 Operating conditions

Owing to the many different laser processing machines and the resulting large variety of different operating conditions it is impossible to define standardized conditions for the noise emission measurements. Therefore the operating conditions used for measurement shall both represent the typical usage of the equipment and the typical noisiest operation. It shall be defined by the manufacturer and clearly described in the noise emission declaration. Technical aspects to be observed are given in Clause A.9.

Operating conditions shall be identical for determining both the emission sound pressure level at the specified measuring positions and also the sound power level.

To define a suitable operating condition the following aspects shall be considered:

a) Process area

   — kind of laser operation and parameters;

   — kind of gas nozzles and parameters;

   — kind of handling system and parameters.

b) Laser device and component parts

   — kind of chiller and operating parameters;

— kind of fans (power supply) and operating parameters;

— kind of exhaust system and operating system.

Where work cycles are used for measurement they shall be clearly defined. The measurement time shall be at least 15 s.

A.5 Measurement uncertainty

The total measurement uncertainty of the noise emission values determined according to this standard is depending on the standard deviation σ_{R0} given by the applied noise emission measurement method (different radiation characteristics of the source under test, different instrumentation, different implementations of the measurement procedure) and the uncertainty associated with the instability of the operating and mounting conditions σ_{omc}. The resulting total uncertainty is then calculated from

$$\sigma_{tot} = \sqrt{\sigma_{R0}^2 + \sigma_{omc}^2}$$

The upper bound value of σ_{R0} is about 1,5 dB for the grade 2 and 3 dB for grade 3 measurement methods dealing with the determination of the emission sound pressure level or the sound power level.

For machines with a rather constant noise emission, a value of 0,5 dB for σ_{omc} can apply. In other cases, e.g. a large influence of the material flow into and out of the machine or material flow that varies in an unpredictable manner, it is possible that a value of 2 dB may be more appropriate. Methods to determine σ_{omc} are described in the basic measurement standards.

The expanded measurement uncertainty U, in decibels, shall be calculated from $U = k\,\sigma_{tot}$, with k the coverage factor.

NOTE The expanded measurement uncertainty depends on the degree of confidence that is desired. For the purpose of comparing the result with a limit value, it is appropriate to apply the coverage factor for a one-sided normal distribution. In that case, the coverage factor $k = 1,6$ corresponds to a 95 % confidence level. Further information is given in ISO 4871. Please note that the expanded measurement uncertainty U is denoted as K in ISO 4871.

A.6 Information to be recorded

The information to be recorded covers all of the technical requirements of the noise test code. Any deviations from the noise test code or from the basic standard(s) upon which it is based are to be recorded together with the technical justification for such deviations.

A.7 Test report

The test report of the noise measurements shall include the following information, in addition to the noise emission declaration (see Clause A.8):

a) type, classification and technical data, dimensions, as well as manufacturer, machine serial number and year of manufacture of the machine tested;

b) any installation and operating condition used to determine the noise emission values during the test (see Clauses A.3 and A.4) that are not specified in Tables A.3 to A.5;

c) basic standards applied for the determination of the noise emission (see Clauses A.1 and A.2), giving, where applicable, reasons for not using accuracy grade 2 methods;

d) measurement results:

— emission sound pressure level L_{pA} at work station and other specified positions;

— if required, A-weighted sound power level L_{WA} or if relevant the emission sound pressure levels L_{pA} at defined positions following a measuring path according to A.2.2;

— when work cycles are split into subcycles, measuring results shall be provided for each subcycle;

— if required the C-weighted peak emission sound pressure level (according to ISO 4871), L_{pCpeak}

e) locations of workstations and of measurement positions if they deviate from Tables A.3 to A.5 or are not specified there;

f) place, date and person responsible for the test.

A.8 Declaration and verification of noise emission values

The declaration of the noise emission values is the sole responsibility of the manufacturer or his appointed representative.

The declaration of the noise emission values shall be made as a dual number noise emission declaration according to ISO 4871.

It shall declare the emission sound pressure level L_{pA} and the respective uncertainty K_{pA} and if required additionally the sound power level L_{WA} and the uncertainty K_{WA}. In the case of impulsive noise, it may be required to declare the L_{pCpeak}.

NOTE 1 The uncertainties K_{pA} and K_{WA} are expected to have values as given in Table A.1.

Table A.1 — Uncertainty values for K_{pA} and K_{WA}

Reference	Accuracy grade 2	Accuracy grade 3
ISO 11201 grade 2	K_{pA} = 3 dB	—
ISO 11202	K_{pA} = 3 dB	K_{pA} = 4 dB
ISO 11204	K_{pA} = 3 dB	K_{pA} = 4 dB
ISO 3744	K_{WA} = 3 dB	—
ISO 3746	—	K_{WA} = 4 dB
ISO 9614-2	K_{WA} = 3 dB	K_{WA} = 4 dB

The noise emission declaration shall state that the noise emission values have been obtained according to this noise test code and to one of the basic standards ISO 3744, ISO 3746, ISO 9614-2, ISO 11201 grade 2, ISO 11202, ISO 11203 or ISO 11204. If this statement is not true, the noise emission declaration shall indicate clearly what the deviations are from this noise test code and/or from the basic standards.

The emission values shall be rounded to the highest decibel.

If undertaken, verification shall be carried out according to ISO 4871 by using the same mounting, installation and operating conditions as those used for the initial determination of the noise emission values.

NOTE 2 An example of a dual-number noise emission declaration is given in Table A.2. The noise emission values given are typical values and are only for illustration.

Table A.2 — An example of a dual-number noise emission declaration

Machine model number, and other identifying information: Type 990, Model 11-TC, 50 Hz, 440 V. Noise test code: ISO/IEC 11553-3:2012, Annex A Table A.3 – Accuracy grade 2. Operating conditions: (*To be specified as required in ISO/IEC 11553-3:2012, Clause A.9*). DECLARED DUAL-NUMBER NOISE EMISSION VALUES according to ISO 4871. In accordance with ISO/IEC 11553-3.		
	Operating mode 1	**Operating mode 2**
Measured A-weighted sound power level, L_{WA} (ref 1 pW) in decibels	88	95
Uncertainty, $K_{WA,}$ in decibels	2	2
Measured A-weighted emission sound pressure level, L_{pA} (ref. 20 µPa) at the operator's position in decibels.	78	86
Uncertainty, $K_{pA,}$ in decibels	2	2
Values determined according to the noise test code given in ISO/IEC 11553-3 using type B acoustic standards (ISO 3744, ISO 11201 grade 2)		
NOTE The sum of the measured noise emission characteristics and its associated uncertainty represents an upper boundary of the range of values which is likely to occur in measurements.		

A.9 Specification of the operating conditions and the measurement positions for determining the emission sound pressure level

A.9.1 Laser processing machines

Table A.3 — Specification of the operating conditions and the measurement positions for determining the emission sound pressure level — Laser processing machines

Operating condition of the machine defined by the manufacturer (Using the laser process and work-piece materials intended by the design that generates the typical noisiest operation for normal use)	**Technical data describing the operating condition to be defined** — operating speed in m/min — material or component processed — laser parameters for the process — used complete work cycle
Measurement position(s) at work station(s) and other specified positions	1 m in front of the centre of the operating and control position.
	1 m in front of any manual loading or unloading position (where applicable).

A.9.2 Large laser processing machines

Table A.4 — Specification of the operating conditions and the measurement positions for determining the emission sound pressure level — Large laser processing machines

Operating condition of the machine defined by the manufacturer (Using the laser process and work-piece materials intended by the design that generates the typical noisiest operation for normal use)	**Technical data describing the operating condition to be defined** — operating speed in m/min — material or component processed — laser parameters for the process — used complete work cycle
Measurement position(s) at work station(s) and other specified positions	1 m in front of the centre of the operating and control position.
	The measuring path according to A.2.2.

Examples for large laser processing machines are large flat-bed laser machines or robotic laser machines.

A.9.3 Hand-held laser processing devices

Table A.5 — Specification of the operating conditions and the measurement positions for determining the emission sound pressure level — Hand-held laser processing devices (HDLs)

Operating condition of the machine defined by the manufacturer (Using the laser process and work-piece materials intended by the design that generates the typical noisiest operation for normal use)	**Technical data describing the operating condition to be defined** — operating speed in m/min — material or component processed — laser parameters for the process — used complete work cycle
Measurement position(s) at work station(s) and other specified positions	**I.** HLDs without remote component parts or HLDs with remote component parts shall be operated by processing typical or intended material. The material shall be placed on a test table and the centre of gravity of the hand-held tool shall be held by an operator or a human simulator just above the centre of the test table. The test table shall be the one described in ISO 11204. The microphone shall be located (0,2 ± 0,02) m to the side of the centre-plane of the operator's or simulator's head, on a line with the eyes, with its axis parallel to the operator's or simulator's line of view, and on the side where the higher value of the sound pressure level is observed. The operator or simulator shall be 1,75 m ± 0,085 m tall. Care should be taken that the noise from the remote component part does not influence the noise emission measurement of the hand-held HLD tool.
	II. For remote component parts of HLDs, the measurements shall be made at four or more microphone positions located 1 m away from each side of the reference box according to ISO 3744 at a height of 1,55 m ± 0,075 m above the ground plane. The value of the highest emission sound pressure level shall be recorded and reported as the emission sound pressure level of the remote component part. The position where this value is measured shall be recorded and reported.

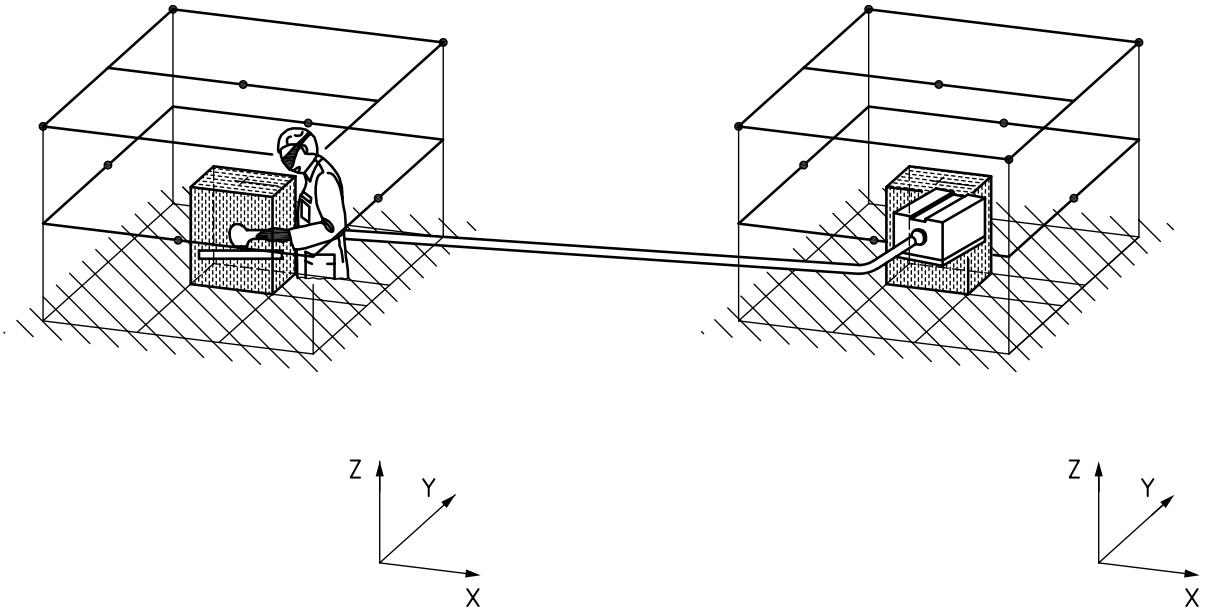

Figure A.1 — Determination of emission sound power level measuring point arrangement according to ISO 3744 for small machines

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[3] ISO 11200:1995, *Acoustics — Noise emitted by machinery and equipment — Guidelines for the use of basic standards for the determination of emission sound pressure levels at a work station and at other specified positions*

[4] ISO/TR 11688-1, *Acoustics — Recommended practice for the design of low-noise machinery and equipment — Part 1: Planning*

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