INTERNATIONAL STANDARD

ISO 8528-10

Second edition
2022-10

Reciprocating internal combustion engine driven alternating current generating sets —

Part 10: Measurement of airborne noise

Groupes électrogènes à courant alternatif entraînés par moteurs alternatifs à combustion interne —

Partie 10: Mesurage du bruit aérien

Reference number
ISO 8528-10:2022(E)

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Published in Switzerland

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 270, *Internal combustion engines*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 8528-10:1998), which has been technically revised.

The main changes are as follows:

— the normative references have been updated;

— the latest requirements of ISO 3744:2010 and ISO 3746:2010 have been included, respecting ISO 12001:1996 requirements;

— the measurement surfaces have been updated;

— the definition of the reference box in special cases has been added;

— the guaranteed sound power level has been added;

— requirements concerning variable speed engine gensets, fans and lighting towers have been added;

— the requirements for welding generators have been updated;

— the determination of the emission sound pressure level at workstation has been updated.

A list of all parts in the ISO 8528 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document specifies noise test codes for determining the basic noise emission descriptors.

For many manufacturers of generating sets, the control of noise is a major issue that requires effective exchange of acoustical information, in particular on noise emission. The basic noise emission descriptors are the sound power level of the generating set itself and the emission sound pressure level at the workstation.

In this context, the main flow of information goes from the manufacturer to the purchaser. However, installers and users of the generating sets also desire comprehensive information about the generating sets' ability to generate airborne sound.

Thus, measuring the basic noise emission descriptors allows the generating set manufacturer to determine, declare and verify the noise emission values.

Therefore, the sound power level, as the major parameter to characterize machines as sound sources, is determined by measurements. The sound power level is a major parameter because it represents an intrinsic characteristic of generating sets as noise sources. It is useful, for example, in noise-abatement programmes or when designing a building where the generating set is intended to be used.

The emission sound pressure level at the workstation is also measured. This enables an assessment of the risk of exposure to the airborne sound of the operators. This assessment is essential for health and safety reasons.

In this document, the generating sets are considered as steady noise sources as per ISO 12001:1996. The generating sets concerned and the extent to which noise is covered are indicated in this document. This document allows measurements to be made in many different test environments. Clause 5 can be used as a general guideline to assist in the selection of the right noise test code. The selection mainly depends on the test environment and the desired grade of accuracy.

This document contains two methodologies for determining the measurement uncertainty. In Clause 12, the uncertainty U is determined by considering measurements on a single generating set. In Clause 13, the uncertainty K is determined by considering a batch of generating sets, which can be useful for control of production purpose.

This document is a C-type standard as stated in ISO 12001:1996. When provisions of this C-type standard are different from those stated in A or B standards, the provisions of this C-type standard take precedence.

Reciprocating internal combustion engine driven alternating current generating sets —

Part 10: Measurement of airborne noise

1 Scope

This document specifies noise test codes for determining the sound power level and the emission sound pressure level at the workstation of reciprocating internal combustion engine driven electrical power generating sets.

This document applies to constant and variable-speed reciprocating internal combustion (RIC) engine driven alternating current (AC) and direct current (DC) generating sets for fixed and mobile applications with rigid or flexible mountings. It is applicable for land and marine use, excluding generating sets used on aircraft or to propel land vehicles and locomotives.

NOTE 1 For some specific applications (e.g. essential hospital supplies, high-rise buildings) supplementary requirements can be necessary. The provisions of this document can be regarded as a basis.

NOTE 2 This document is referenced with regard to noise in ISO 8528-13:2016, which contains requirements concerning the design of generating sets, verification of noise levels and information related to noise in the operating and maintenance instructions.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3046-1:2002, *Reciprocating internal combustion engines — Performance — Part 1: Declarations of power, fuel and lubricating oil consumptions, and test methods — Additional requirements for engines for general use*

ISO 3744:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering methods for an essentially free field over a reflecting plane*

ISO 3746:2010, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane*

ISO 8528-1:2018, *Reciprocating internal combustion engine driven alternating current generating sets — Part 1: Application, ratings and performance*

ISO 8528-2:2018, *Reciprocating internal combustion engine driven alternating current generating sets — Part 2: Engines*

ISO 15619:2013, *Reciprocating internal combustion engines — Measurement method for exhaust silencers — Sound power level of exhaust noise and insertion loss using sound pressure and power loss ratio*

IEC 60942:2017, *Electroacoustics - Sound calibrators*

IEC 60974-1:2021, *Arc welding equipment - Part 1: Welding power sources*

IEC 61260-1:2014, *Electroacoustics - Octave-band and fractional-octave-band filters - Part 1: Specifications*

IEC 61672-1:2013, *Electroacoustics – Sound level meters – Part 1: specifications*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3046-1:2002, ISO 8528-1:2018 and ISO 8528-2:2018 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
emission
<acoustics> airborne sound radiated by the generating set under test

3.2
emission sound pressure
p_e
sound pressure, at a workstation or another specified position near a noise source, when the source is in operation under specified operating and mounting conditions on a reflecting plane surface, excluding the effects of background noise

Note 1 to entry: Emission sound pressure is expressed in pascals.

3.3
emission sound pressure level
L_{pe}
ten times the logarithm to the base 10 of the ratio of the square of the emission sound pressure, p_e, to the square of a reference value, p_0, expressed in decibels by Formula (1):

$$L_{pe} = 10\ lg \frac{p_e^2}{p_0^2} \tag{1}$$

where the reference value, p_0, is 20 µPa

3.4
time-averaged emission sound pressure level
$L_{pe,T}$
ten times the logarithm to the base 10 of the ratio of the time average of the square of the emission sound pressure, p_e, during a stated time interval of duration, T (starting at t_1 and ending at t_2), to the square of a reference value, p_0, expressed in decibels by Formula (2):

$$L_{pe,T} = 10\ lg \left[\frac{\frac{1}{T}\int_{t_1}^{t_2} p_e^2(t)\,dt}{p_0^2} \right] \tag{2}$$

where the reference value, p_0, is 20 µPa

Note 1 to entry: In general, the subscript "T" is omitted, since time-averaged sound pressure levels are necessarily determined over a certain measurement time interval.

Note 2 to entry: L_{peA} denotes the A-weighted emission sound pressure level.

3.5
workstation
operator's position
position in the vicinity of the generating set under test which is intended for the operator

Note 1 to entry: This position is defined as the location in the vicinity of the device(s) mounted to the generating set for work tasks.

Note 2 to entry: Such devices can be a control panel, an emergency stop button or the most likely device on the equipment that an operator would interact with.

Note 3 to entry: A generating set can have more than one workstation.

3.6
operator
individual whose workstation is in the vicinity of a machine and who is performing a work task associated with that machine

4 Symbols

$\cos\varphi$	power factor
d	measurement distance, in metres
D_{Ii}^{*}	apparent directivity index, in decibels
i	subscript denoting a particular measuring point
K	expanded measurement uncertainty of the sound power level, or of the emission sound pressure level at the workstation, for a batch of generating sets, in decibels
$K_{1\mathrm{A}}$	A-weighted background noise correction, in decibels
$K_{2\mathrm{A}}$	A-weighted environmental correction, in decibels
L_{p}	sound pressure level, in decibels
$\overline{L_{\mathrm{p}}}$	surface time-averaged sound pressure level, in decibels
L_{pe}	emission sound pressure level, in decibels
L_{peA}	A-weighted emission sound pressure level, in decibels
$L_{\mathrm{pe,T}}$	time-averaged emission sound pressure level, in decibels
$L_{\mathrm{p}i\mathrm{,T}}$	time-averaged sound pressure level, for the ith microphone position on the measurement surface, in decibels
$L_{\mathrm{p,T}}$	time-averaged sound pressure level, in decibels
L_{W}	sound power level, in decibels
L_{WA}	A-weighted sound power level, in decibels
ΔL_{p}	difference between the time-averaged sound pressure level of the background noise measured and averaged over the microphone positions, and corresponding time-averaged sound pressure level of the noise source under test when measured in the presence of this background noise, in decibels
p	sound pressure, in pascals

r measurement radius, in metres

S measurement surface, in square metres

T measurement time interval, in seconds

U expanded measurement uncertainty of the sound power level, or of the emission sound pressure level at the workstation, for a single generating set, in decibels

V_{I}^{*} apparent surface sound pressure level non-uniformity index, in decibels

5 Selection of the most appropriate method

5.1 General

Table 1 provides a detailed overview of the technical characteristics of the measurements methods in this document. Table 1 describes noise test codes with two levels of accuracy (grades 2 and 3). It can help in the selection of the appropriate noise test code.

Table 1 — Technical characteristics of this document

	Measurement methods		
Parameters	**Sound power level measurement ISO 8528-10 grade 2**	**Sound power level measurement ISO 8528-10 grade 3**	**Emission sound pressure level at the workstation measurement ISO 8528-10 grade 2**
Basic standards referenced	ISO 3744:2010	ISO 3746:2010	ISO 11201:2010
Accuracy	Grade 2 engineering	Grade 3 survey	Grade 2 engineering
Test environment	Indoor or outdoor	Indoor or outdoor	Indoor or outdoor
Type of environment	Dedicated to tests	In situ	Dedicated to tests
Characteristics of environment	Hemi-anechoic rooms, large rooms or unobstructed outdoor area	Not especially designed for acoustic tests	Hemi-anechoic rooms, large rooms or unobstructed outdoor area
Acoustic field	Essentially free field over a reflecting plane	Unspecified field with one or multiple reflecting plane(s)	Essentially free field over a reflecting plane
Generating set volume	Unlimited	Unlimited	Unlimited
Applications as per ISO 12001:1996	Noise declaration engineering study for noise reduction	Comparative tests	Noise declaration engineering study for noise reduction
Obtainable quantities	A-weighted sound power level	A-weighted sound power level	A-weighted sound pressure level
	Frequency bands (octave) sound power level		Frequency bands (octave) sound pressure level
	Frequency bands (one-third octave) sound power level		Frequency bands (one-third octave) sound pressure level
Criterion for background noise	$\Delta L_p \geq 6$ dB $K_{1A} \leq 1{,}3$ dB	$\Delta L_p \geq 3$ dB $K_{1A} \leq 3$ dB	$\Delta L_p \geq 6$ dB $K_{1A} \leq 1{,}3$ dB

[a] For indoor measurements only.

[b] Specific studies carried out on generating sets can lead to lower values.

Table 1 *(continued)*

Parameters	Measurement methods		
	Sound power level measurement ISO 8528-10 grade 2	**Sound power level measurement ISO 8528-10 grade 3**	**Emission sound pressure level at the workstation measurement ISO 8528-10 grade 2**
Criterion for acoustic adequacy of test environment	$K_{2A} \leq 4$ dB	$K_{2A} \leq 7$ dB	$K_{2A} \leq 4$ dB[a]
Instrumentation	Class 1	Class 2	Class 1
Typical upper bound values of the standard deviation of reproducibility[b]	1,5 dB	4 dB	1,5 dB

[a] For indoor measurements only.

[b] Specific studies carried out on generating sets can lead to lower values.

5.2 Sound power level measurements accuracy grades

5.2.1 General

For sound power level measurements:

— Grade 2 provides more accurate results than grade 3 but involves greater measurement efforts.

— The grade 2 method is based on ISO 3744:2010. The requirements listed in Annex A shall be followed.

— Terms and definitions of ISO 3744:2010 applicable to generating sets are indicated in Table A.1.

— The grade 3 method is based on ISO 3746:2010. The requirements listed in Annex B shall be followed.

— Terms and definitions of ISO 3746:2010 applicable to generating sets are indicated in Table B.1.

— In this document, when the accuracy grade is not specified the requirements apply for grade 2 and grade 3. The grade 3 method has many requirements in common with the grade 2 method.

5.2.2 Engineering grade (grade 2)

In this accuracy grade, the acoustic environment is analysed to determine its effect upon the measurements. The environmental correction K_{2A} shall be less than or equal to 4 dB. The background noise level is analysed too. Background noise correction K_{1A} shall be less than or equal to 1,3 dB. The measuring points are selected according to the characteristics of the generating set. The engineering method is the preferred method for noise declaration purposes. This method usually provides information that is sufficient for taking engineering action in many situations, for example, in connection with noise-abatement programmes.

5.2.3 Survey grade (grade 3)

This accuracy grade needs less time and equipment than grade 2. It may be used for comparison between generating sets with similar characteristics. The measurements are made in situ with little effort expended to control the acoustic environment in which the generating set operates. The environmental correction K_{2A} shall be less than or equal to 7 dB. The background noise correction K_{1A} shall be less than or equal to 3 dB. The survey method is generally of limited value if corrective measures to reduce the noise are to be evaluated.

NOTE True comparisons can only be made between generating sets when the measurements are classified in the same accuracy grade.

6 Measuring equipment

6.1 General

ISO 3744:2010, 5.1 and ISO 3746:2010, 5.1 are replaced by subclause A.2.1.

6.2 Calibration

ISO 3744:2010, 5.2 and ISO 3746:2010, 5.2 are replaced by subclause A.2.2.

7 Measuring environment

7.1 General

For accuracy grade 2, ISO 3744:2010, 1.3, and 4.1 apply.

For accuracy grade 3, ISO 3746:2010, 1.3, and 4.1 apply.

7.2 Verification of acoustic adequacy of test environment

For accuracy grade 2, the test environment shall meet the requirements of ISO 3744:2010, 4.3. In addition, the following considerations shall be taken into account:

— Where it is decided to make measurements in frequency bands, the relevant environmental correction K_2 shall be determined in each band over the frequency range of interest in accordance with A.6.

— In many cases, due to the reality of the acoustic properties of the measuring area and the test bench conditions (this occurs predominantly with larger generating sets), sound power level grade 2 might not be obtainable using the method described in this document. In special cases with the agreement of the customer or the accepting company or authority, the accuracy may be improved with the use of special measuring methods (e.g. sound intensity method in accordance with ISO 9614-1:1993 and ISO 9614-2:1996, see Annex C).

For accuracy grade 3, the test environment shall meet the requirements of ISO 3746:2010, 8.1 and 4.3.

7.3 Criteria for background noise

For accuracy grade 2, the background noise shall meet the requirements of ISO 3744:2010, 4.2.

For accuracy grade 3, the background noise shall meet the requirements of ISO 3746:2010, 4.2.

In both cases, the following additional considerations shall be taken into account:

— Noise generated by air movement at the microphone itself is classified as background noise.

— For measuring out of doors, a microphone wind cover in accordance with the microphone manufacturer's specifications shall be used.

— When measurements are done outside, the maximum speed of the wind shall not exceed 6 m/s.

8 Definition of noise source and operating conditions of the generating set

8.1 Definition of noise source under test

The noise of a generating set is defined as the total noise emitted by that generating set. This includes the surface noise of the engine and the AC or DC alternator, the air intake and discharge noise, exhaust

noise (including the genset muffler, rain cap and tail pipe exhaust outlet), the noise emitted from the cooling system of the power generator set, the radiator and other fans of the power generator, and the noise which is emitted, for example, from the joining sections and the base frame, chassis and fuel tank.

In the case of totally or partially encapsulated generating sets, the surface noise is the noise emitted from the enclosure.

If, as in special cases, one of the above-mentioned noise emissions is not in the measurement results, then this shall be recorded in the measuring report. Such special cases include:

— in situ: when the exhaust and cooling systems are ducted to a remote site.

— in a test room: when the exhaust of the generating set is ducted out of the test room.

8.2 Location, installation of the generating set

For accuracy grade 2, the generalities in ISO 3744:2010, 6.1 apply.

For accuracy grade 3, the generalities in ISO 3746:2010, 6.1 apply.

For accuracy grade 2, ISO 3744:2010, 6.3, concerning noise source location, shall apply.

For accuracy grade 3, ISO 3746:2010, 6.3, concerning noise source location, shall apply.

In addition, the following considerations shall be taken into account:

— The generating set shall be prepared in accordance with the instructions given by the manufacturer.

— If simulated loading conditions are used, they shall be chosen such that the sound power levels of the source under test are representative of normal use.

8.3 Mounting of the generating set

For accuracy grade 2, ISO 3744:2010, 6.4.1, concerning generalities about mounting of the noise source, shall apply.

For accuracy grade 3, ISO 3746:2010, 6.4.1, concerning generalities about mounting of the noise source, shall apply.

For accuracy grade 2, ISO 3744:2010, 6.4.3, concerning base-mounted, wall-mounted and tabletop machinery and equipment, shall apply.

For accuracy grade 3, ISO 3746:2010, 6.4.3, concerning base-mounted, wall-mounted and tabletop machinery and equipment, shall apply.

In addition, the following considerations shall be taken into account:

— For accuracy grade 2, the generating set shall be installed on a typical noise-reflecting ground plane of concrete or non-porous asphalt, in an essentially free-field environment. Refer to the free-field environment definition from ISO 3744:2010.

— For accuracy grade 2 and grade 3, the generating set shall be installed according to the manufacturer's recommendation, representative of a typical operational installation. This shall consider the location of any discrete items (e.g. cooling, aftertreatment, exhaust) and mounting (e.g. trailer with stabilizing jacks, skid).

8.4 Operation of the generating set during test

ISO 3744:2010, 6.6 and ISO 3746:2010, 6.5 are replaced by subclause A.3.

9 Reference box and measurement surface

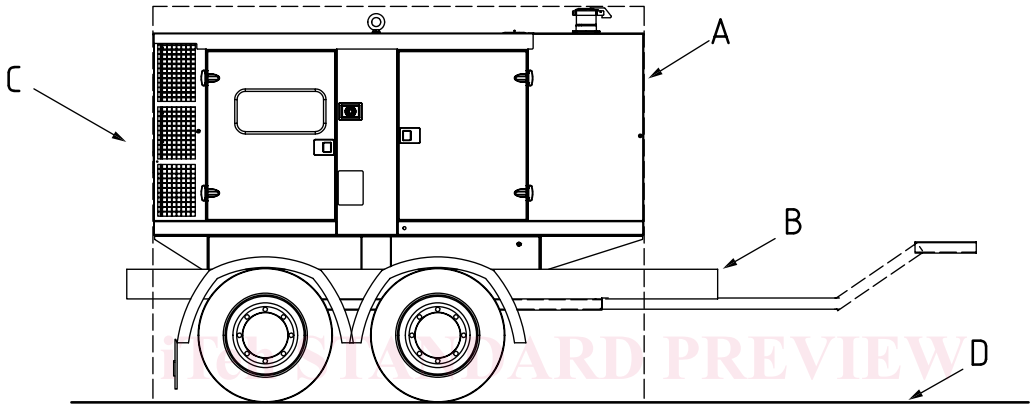
9.1 Reference box

ISO 3744:2010, 7.1 and ISO 3746:2010, 7.1 are replaced by subclause A.4.

9.2 Determination of the reference box in special cases

9.2.1 Elevated generating set on a trailer or trolley kit

In cases where the generating set is elevated (e.g. on a trailer or a trolley kit) in normal customer use, the reference box shall be delineated as per 9.1. An example is given in Figure 1.



Key

A generating set
B trailer
C reference box
D ground (reflecting plane)

Figure 1 — Example of a reference box for a generating set on a trailer

9.2.2 Generating set with extended exhaust device

In cases where the generating set is installed outdoors, with a vertical extended exhaust device, the reference box shall be delineated depending on the value of m in the following cases. m is the distance between the exhaust outlet of the generating set and the uppermost noise-emitting devices' top surface.

Case 1: If $m > 2$ metres then a reduced reference box shall be used, including the uppermost noise emitting devices' top surface, but excluding the exhaust outlet. An example is given in Figure 2 a).

Case 2: If 1 metre $\leq m \leq 2$ metres, then the exhaust outlet shall be temporarily extended to have $m > 2$ metres. Then a reduced reference box shall be used, including the uppermost noise emitting devices' top surface, but excluding the exhaust outlet. An example is given in Figure 2 a).

This extension is for measurement purposes only.

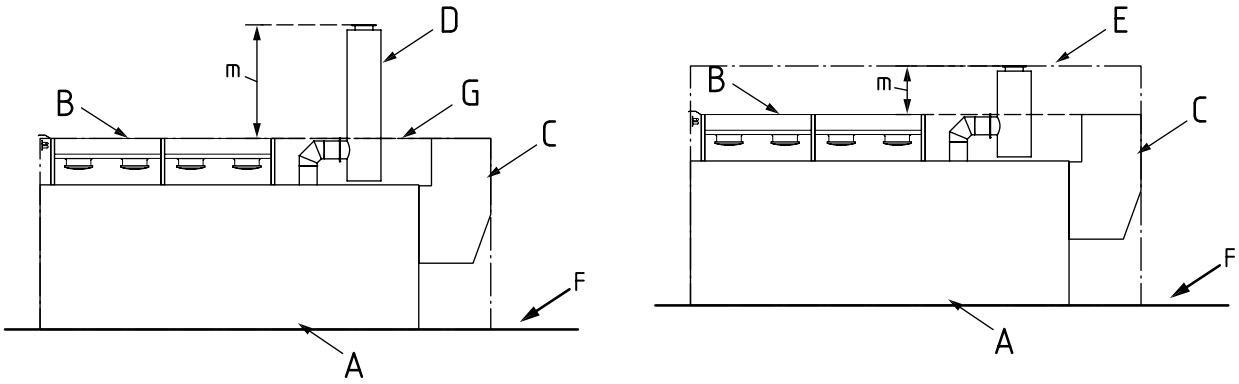
Case 3: If $m < 1$ metre then regular reference box shall be used, including the exhaust outlet. An example is given in Figure 2 b).

With respect to cases 1 and 2, two components of sound power level (L_{WA}) shall be determined. The first component, L_{WA1}, shall be determined by taking into consideration the reduced reference box, where sound power level emitted by the genset excluding the exhaust system is determined. The second

component, L_{WA2}, is the sound power level of the exhaust outlet. L_{WA2} shall be determined by using the ISO 15619:2013 accuracy grade 2 method. Then Formula (3) shall be used.

$$L_{WA} = 10\ \lg\left[\left(10^{(L_{WA1}/10)}\right) + \left(10^{(L_{WA2}/10)}\right)\right] \quad (3)$$

In cases where the generating set is installed outdoors, with a remote exhaust device on the side, the same requirements as detailed above shall apply.



a) **b)**

Key

A	generating set	E	reference box
B	cooling system	F	ground (reflecting plane)
C	air intake	G	reduced reference box
D	vertical extended exhaust device		

Figure 2 — Example of reference boxes for generating sets with a vertical extended exhaust device

9.2.3 Generating set with auxiliary equipment

In cases with auxiliary equipment that is necessary for the operation of the generating set but not part of it (e.g. load banks), ISO 3744:2010, 6.2 or ISO 3746:2010, 6.2 shall apply.

In cases where there are auxiliary equipment that are necessary for the operation of the generating set that are parts of it, ISO 3744:2010, 6.2, or ISO 3746:2010, 6.2 shall apply.

9.3 Measurement surface

9.3.1 General

ISO 3744:2010, 7.2.1 and ISO 3746:2010, 7.2.1 are replaced by subclause A.5.1.

9.3.2 Microphone orientation

For accuracy grade 2, ISO 3744:2010, 7.2.2 shall apply.

For accuracy grade 3, ISO 3746:2010, 7.2.2 shall apply.

In addition, the following considerations shall be taken into account:

— In an effort to reduce the influence on measured results due to people involved in the measuring process, the microphone shall preferably be mounted statically.