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Reciprocating internal combustion engine driven current generating sets —

Part 10:

Measurement of airborne noise by the enveloping surface method

ICS: 27.020; 17.140.20; 29.160.40

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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).

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This document was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*.

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

The main changes compared to the previous edition 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 Annex ZA has been updated;
- the definition of the reference box in special cases has been added;
- the determination of the sound pressure level at workstation has been updated;
- 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

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.

1 Introduction

This document specifies noise test codes for determining the sound power levels of reciprocating internal combustion engine driven electrical power generating sets.

For many manufacturers of generating sets, the control of noise is a major issue with effective exchange of acoustical information in particular on the sources' noise emission. In this context the main flow of information goes from the manufacturer to the purchaser. However, also installers and users of the generating sets are interested to get comprehensive information about the sound sources ability to generate airborne sound.

Therefore the sound power level, as the major parameter to characterise machines as sound sources, need to be determined by measurements. The sound power level is a major parameter because it represents an intrinsic characteristic of generating sets as noise sources, that is independent of the environment in which it is installed.

Measuring the sound power level allows the generating sets manufacturer to determine, declare and verify the noise emission values.

In this document the sound power level is determined by using sound pressure level that is measured over a measurement surface enclosing the generating set. 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 to make measurements in a lot of different test environments. Table 1 can be used as 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 is C-type standard as stated in ISO 12001:1996. When provisions of this C-type standard are different from those which are stated in A or B standards, the provisions of this C-type standard take precedence.

Reciprocating internal combustion engine driven current generating sets — Part 10: Measurement of airborne noise by the enveloping surface method

2 Scope

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.

The relationship between this standard and the essential requirements of European Directive 2006/42/EC are detailed in the Annex ZA.

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

NOTE 2 This international standard is referred in the EN ISO 8528-13 with regard to noise. EN ISO 8528-13 contains requirements concerning the design of generating sets, verification of noise levels, information related to noise in the operating and maintenance instructions.

3 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, *Reciprocating internal combustion engines — Performance — Part 1: Standard reference conditions, declarations of power, fuel and lubricating oil consumptions and test methods*

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

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

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*

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

IEC 61260, *Electroacoustics. Octave-band and fractional-octave-band filters.*

IEC 60942, *Electroacoustics - Sound calibrators*

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

4 Terms and definitions

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

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

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

For acoustics, terms and definitions of ISO 3744:2010 applicable to generating sets are indicated in [Table B.1](#); terms and definitions of ISO 3746:2010 applicable to generating sets are indicated in Table C.1.

5 Symbols

d_0	Characteristic source dimension, in meters
d	Measurement distance, in meters
r	Measurement radius, in meters
S	Measurement surface, in square meters
p	Sound pressure, in pascals
i	Subscript denoting a particular measuring point
L_p	Sound pressure level, in decibels
T	Measurement time interval, in seconds
$L_{p,T}$	Time-averaged sound pressure level, in decibels
$L_{p,i,T}$	Time-averaged sound pressure level, for the i th microphone position on the measurement surface, in decibels
K_{1A}	A-weighted background noise correction, in decibels
K_{2A}	A-weighted environmental correction, in decibels
$\overline{L_p}$	Surface time-averaged sound pressure level, in decibels
L_W	Sound power level, in decibels
L_{WA}	A-weighted sound power level, in decibels
D_{Ii}^*	Apparent directivity index, in decibels
V_I^*	Apparent surface sound pressure level non-uniformity index, in decibels
ΔL_p	Difference between the time-averaged sound pressure level of the background noise measured and averaged over the microphone positions on the measurement surface, and corresponding time-averaged sound pressure level of the noise source under test when measured in the presence of this background noise, in decibels
$\cos\varphi$	Power factor

6 Technical characteristics of the ISO 8528-10

Table 1 – Technical characteristics of the ISO 8528-10

Parameters	Noise measurement ISO 8528-10 grade 2	Noise measurement ISO 8528-10 grade 3
Basic Standards referenced	ISO 3744:2010	ISO 3746:2010
Accuracy	Grade 2 Engineering	Grade 3 Survey
Test environment	Indoor or outdoor	Indoor or outdoor
Type of environment	Dedicated to tests	In-situ
Characteristics of environment	Hemi-anechoic rooms, large rooms, or unobstructed outdoor area	Not especially designed for acoustic tests
Acoustic field	Essentially free field over a reflecting plane	Unspecified field with one or multiple reflecting plane(s)
Generating set volume	Unlimited	Unlimited
Applications as per ISO 12001:1996	Noise declaration Engineering study for noise reduction	Comparative tests
Obtainable sound power level	A-weighted overall level	A-weighted overall level
	Frequency bands (octave)	
	Frequency bands (one-third octave)	
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
Criterion for acoustic adequacy of test environment	ISO/DIS 8528-10 $K_{2A} \leq 4$ dB	$K_{2A} \leq 7$ dB
Instrumentation	Class 1	Class 2
Typical upper bound values of the standard deviation of reproducibility ^a	1,5 dB	4 dB

^a Specific studies carried out on generating sets may lead to lower values

This document describes noise test codes with two levels of accuracy (grade 2 and 3). Grade 2 provides more accurate results than grade 3, but involves greater measurement efforts.

Grade 2 method is based on the Basic Standard ISO 3744:2010. Annex B presents how the ISO 3744:2010 is applied for the generating sets.

Grade 3 method is based on the Basic Standard ISO 3746:2010. Annex C presents how the ISO 3746:2010 is applied for the generating sets.

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

Engineering grade (grade 2)

In this method, the acoustic environment is analysed to determine its effect upon the measurements. The environmental correction K_{2A} shall be less or equal to 4 dB. The background noise level is analysed to. Background noise correction K_{1A} shall be less 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.

For the operation of a generating set under steady conditions this document allows for the calculation of the A-weighted sound power level as well as octave or one third octave sound power level.

Survey grade (grade 3)

This method needs less amount of time and equipment than grade 2 method. 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 or equal to 7 dB. The background noise correction K_{1A} shall be less or equal to 3 dB. This method allows to obtain the A-weighted sound power level (not frequency-band sound power level). 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.

7 Measuring equipment**7.1 General**

ISO 3744:2010, 5.1 and ISO 3746:2010, 5.1 are replaced by Annex B, paragraph [B.2.1](#).

7.2 Calibration

ISO 3744:2010, 5.2 and ISO 3746:2010, 5.2 are replaced by Annex B, paragraph [B.2.2](#).

8 Measuring environment**8.1 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.

8.2 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_{2A} shall be determined in each band over the frequency range of interest in accordance with paragraph B.6 and all measurements to determine L_W of the generating set under test shall be made in frequency bands.

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) grade 2 may not be obtainable using the method described in this Standard. 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 and ISO 9614-2, see Annex D).

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

8.3 Criteria for background noise

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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, in addition, the following 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 specification, shall be used. When measurements are done outside the maximum speed of the wind shall not exceed 6 m/s.

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

9.1 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 alternating or direct current alternator, the air intake and discharge noise, exhaust noise (including the genset muffler, rain cap, tail pipe exhaust outlet) and the noise emitted from the cooling system of the power generator set and the radiator and other fans of the power generator and also the noise which will, for example, be emitted from the joining sections and the base frame, chassis, fuel tank etc...

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

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

- 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.

9.2 Location, installation of the generating set

The generalities in ISO 3744:2010, 6.1 or ISO 3746:2010, 6.1 apply.

ISO 3744:2010, 6.3, or ISO 3746:2010, 6.3, concerning noise source location shall be applied.

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.

9.3 Mounting of the generating set

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ISO 3744:2010, 6.4.1, or ISO 3746:2010, 6.4.1 concerning generalities about mounting of the noise source shall be applied.

ISO 3744:2010, 6.4.3, or ISO 3746:2010, 6.4.3 concerning base-mounted, wall-mounted, and tabletop machinery and equipment shall be applied.

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 nonporous asphalt, in an essentially free-field environment. Refer free-field environment definition from ISO 3744:2010.

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

9.4 Operation of the generating set during test

ISO 3744:2010, 6.6, and ISO 3746:2010, 6.5 are replaced by Annex B, [B.3](#).

10 Reference box and measurement surface

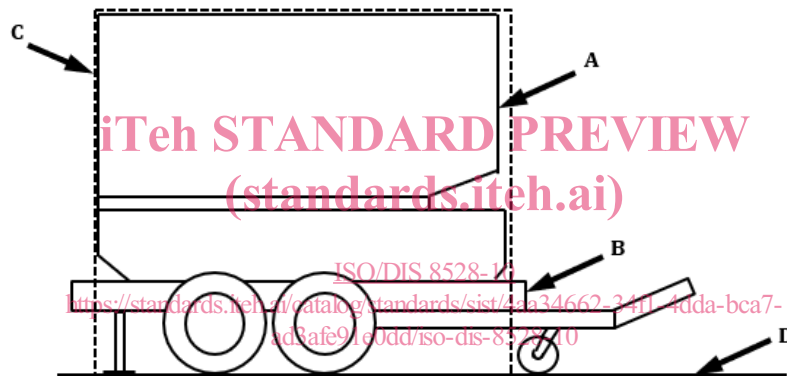
10.1 Reference box

ISO 3744:2010, 7.1 and ISO 3746:2010, 7.1 are replaced by Annex B, [B.4](#).

10.2 Determination of the reference box in special cases

10.2.1 Elevated generating set on a trailer or trolley kit

In the case where the generating set is elevated (for example on a trailer or a trolley kit) in customer normal use, the reference box shall be delineated as per 10.1. An example is given in Figure 1 below.



Key

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

Figure 1 — Reference box for a generating set on a trailer (informative example)

10.2.2 Generating set with extended exhaust pipe

In the case where the generating set is installed outdoor, with a vertical extended exhaust pipe, 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 upper most noise emitting devices' top surface.

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

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

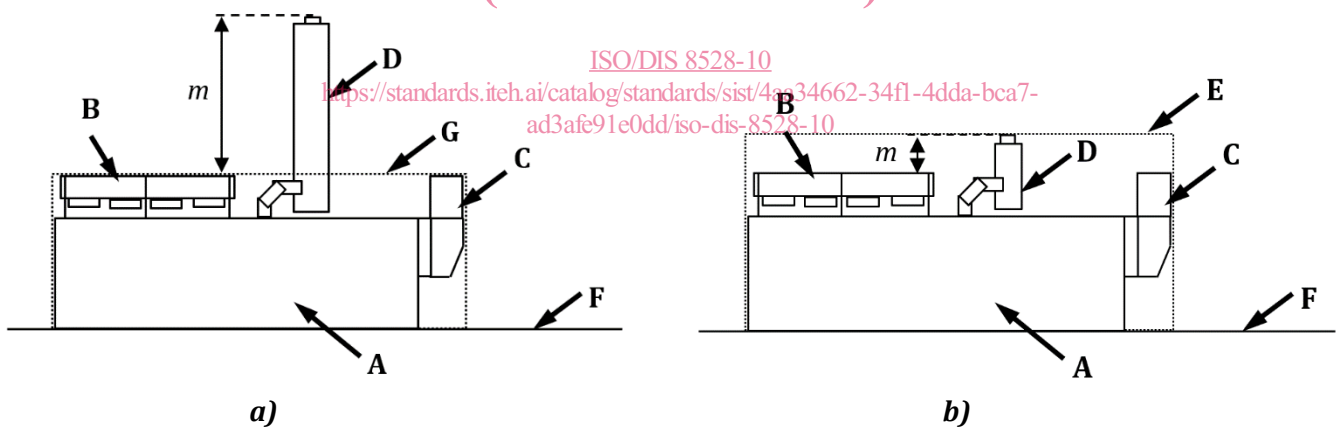
Note: this extension is for measurement purposes only

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

With respect to the 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 in 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 ISO 15619:2013 accuracy grade 2 method. Then Formula (1) shall be used.

$$L_{WA} = 10 \lg[(10^{(L_{WA1}/10)}) + (10^{(L_{WA2}/10)})] \quad (1)$$

In the case where the generating set is installed outdoor, with a remote exhaust pipe on the side, the same requirements as detailed above shall be applied.



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 pipe		

Figure 2 — Reference boxes for generating sets with a vertical extended exhaust pipe (informative example)