
**Earth-moving machinery —
Determination of sound power level —
Stationary test conditions**

*Engins de terrassement — Détermination du niveau de puissance
acoustique — Conditions d'essai statique*

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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 6393 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*, in collaboration with Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*.

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This third edition cancels and replaces the second edition (ISO 6393:1998), which has been technically revised.

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Introduction

This International Standard is a specific test code for earth-moving machinery as defined in ISO 6165.

Specific procedures are described in this International Standard to enable the sound power emission in stationary test conditions to be determined in a manner which is repeatable. Attachments (bucket, dozer, etc.) for the manufacturer's production version are intended to be fitted since this is the configuration most likely to exist when the machine is in actual use.

This International Standard enables compliance with noise limits to be determined. It can also be used for evaluation purposes in noise reduction investigations.

A complementary test code is given in ISO 6394. This other specific test code is intended to be used to determine the noise emitted by earth-moving machinery, measured at the operator's position in terms of the A-weighted sound pressure level, with the machine under stationary test conditions.

Corresponding measurements of noise emitted to the environment and noise at the operator's position under dynamic test conditions are described in ISO 6395 and ISO 6396 respectively.

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Earth-moving machinery — Determination of sound power level — Stationary test conditions

1 Scope

This International Standard specifies a method for determining the noise emitted to the environment by earth-moving machinery, measured in terms of the A-weighted sound power level while the machine is stationary and with the engine operating at the rated speed under no-load conditions.

It is applicable to earth-moving machinery as specified in Annex A and as defined in ISO 6165.

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:—¹⁾, *Acoustics — Determination of sound power levels and sound energy levels of noise sources using sound pressure — Engineering method for an essentially free field over a reflecting plane*

ISO 6165, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 9249, *Earth-moving machinery — Engine test code — Net power*

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 3744 and ISO 6165, and the following, apply.

3.1

time-averaged A-weighted sound pressure level

$L_{pA,T}$

A-weighted sound pressure level averaged on an energy basis over the whole measurement period, T

3.2

A-weighted sound power level

L_{WA}

quantity obtained from the time-averaged A-weighted sound pressure levels averaged over the measurement surface on an energy basis

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

**3.3
basic length**

l
length used to define the radius of the measurement hemisphere

NOTE The dimension of the basic length, l , is determined in Annex A.

3.4 Machine centre point

**3.4.1
machine centre point**

⟨all machines, except those with slewing upper structure⟩ midpoint of the basic length, l , at the machine longitudinal centreline

**3.4.2
machine centre point**

⟨machines with slewing upper structure⟩ centre of rotation of the upper structure

3.5 Fan speed

**3.5.1
maximum working speed of the fan**

fan speed at which the fan provides maximum cooling performance for the machine under the most severe operating conditions

**3.5.2
fan drive with continuous variable fan speed**

fan drive that varies the fan speed continuously throughout a variable range to minimize its speed for the needed cooling performance in relation to the heat load

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4 Instrumentation

The instrumentation shall be capable of carrying out the measurements according to Clause 8. The preferred instrumentation system for acquiring the data is an integrating-averaging sound level meter complying with the requirements of IEC 61672-1 for a class 1 instrument.

5 Test environment

5.1 General

For the purposes of this International Standard, the test environment specified in ISO 3744:—, Clause 4 and Annex A, apply. Additional requirements are given in 5.2 to 5.5.

Humidity, air temperature, barometric pressure, vibration and stray magnetic fields shall be within the limits specified by the manufacturer of the instrumentation.

5.2 Test site and environmental correction, K_{2A}

For test-site measurement ground surfaces consisting of a hard reflecting plane — such as concrete or non-porous asphalt [5.3.1 a) and b)] — and having negligible sound-reflecting obstacles within a distance from the source equal to three times the measurement hemisphere radius, it may be assumed that the absolute value of environmental correction, K_{2A} , is less than or equal to 0,5 dB and can therefore be disregarded.

For the all-sand test site [5.3.1 c)], the value of environmental correction, K_{2A} , shall be determined and used in the sound power calculation.

5.3 Test site

5.3.1 General

The following three types of test-site measurement ground surface, described in 5.3.2, 5.3.3 and 5.3.4, are allowed:

- a) hard reflecting plane (concrete or non-porous asphalt);
- b) combination of hard reflecting plane and sand;
- c) all-sand plane.

The hard reflecting plane, as described in 5.3.2, shall be used for the stationary measurement of all machines.

The combination of hard reflecting plane and sand, as described in 5.3.3, may be used for rollers with raised pads and landfill compactors.

The combination of hard reflecting plane and sand, as described in 5.3.3, or the all-sand plane, as described in 5.3.4, may be used for crawler-type machines, except crawler-type excavators, provided that

- the environmental correction, K_{2A} , determined in accordance with ISO 3744:—, Annex A, is less than 2,0 dB, and
- for the all-sand plane as described in 5.3.4, where K_{2A} is greater than 0,5 dB, the correction is accounted for in the calculation of the sound power level.

5.3.2 Hard reflecting plane

The test area bordered by the vertical projection of the microphones to the ground shall consist of concrete or non-porous asphalt.

5.3.3 Combination of hard reflecting plane and sand

The test site for the machine shall consist of humid sand of grain size up to 2 mm. The minimum depth of the sand shall be 0,3 m. If 0,3 m is not deep enough for track penetration, the depth shall be increased accordingly. The ground surface between the machine and the microphones shall be a hard reflecting plane, as described in 5.3.2.

It is possible to use a combination site of minimum size comprising only a single reflecting plane with a sand path along the side. In this case, a set of measurements with three microphones shall be carried out on one side of the machine. Another set shall then be carried out for the other side after turning the machine 180°.

5.3.4 All-sand plane

The sand shall be as specified in 5.3.3.

5.4 Background noise correction, K_{1A}

The requirements for background noise, as specified in ISO 3744, shall be fulfilled. Corrections for background noise shall be made as specified in ISO 3744:—, 8.3.2.

5.5 Climatic conditions

Measurements shall not be carried out under the following conditions:

- a) when there is precipitation, i.e. rain, snow or hail;
- b) when the ground surface is covered with snow;
- c) when the temperature is below $-10\text{ }^{\circ}\text{C}$ or above $+35\text{ }^{\circ}\text{C}$;
- d) when wind speed exceeds 8 m/s; for wind speeds in excess of 1 m/s, a microphone windscreen shall be used, and appropriate compensation for the effect of its use shall be allowed for when calibrating.

6 Measurement of time-averaged A-weighted sound pressure levels

6.1 Size of measurement surface

The measurement surface to be used for the test shall be a hemisphere. The radius of the hemisphere shall be determined by the basic length, l , of the machine as specified in Annex A. The basic length includes the main body of the machine and excludes major attachments, such as dozer blades, bucket and boom.

The radius shall be

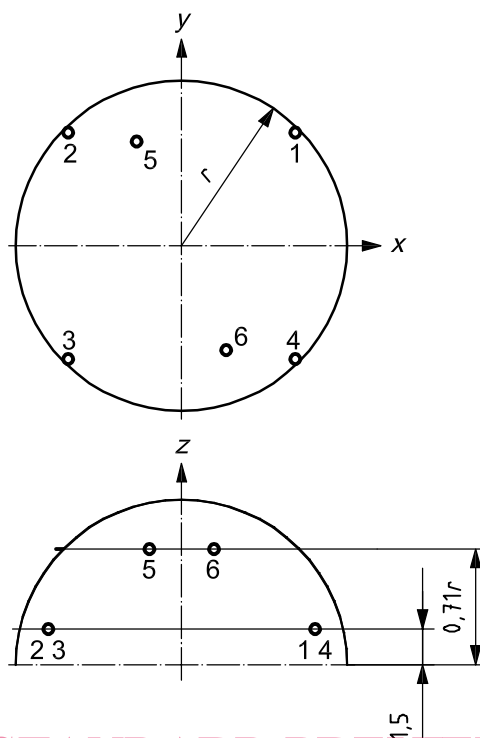
- 4 m when the basic length, l , of the machine to be tested is less than 1,5 m.
- 10 m when the basic length, l , of the machine to be tested is greater than or equal to 1,5 m but less than 4 m,
- 16 m when the basic length, l , of the machine to be tested is greater than or equal to 4 m but less than 8 m, and
- the smallest radius of the sequence, 16 m, 18 m, 20 m... when the basic length, l , of the machine to be tested is greater than 8 m and the hemisphere radius exceeds twice the characteristic length, d_0 , of the machine to be tested.

NOTE Characteristic length, d_0 , is as defined in ISO 3744, with the machine length, l , equal to l_1 .

6.2 Microphone positions on the hemispherical measurement surface

Six measuring positions shall be used. Microphone positions and their coordinates shall be as shown in Figure 1 and as given in Table 1.

Dimensions in metres



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Key

- 1 to 6 microphone positions
 r hemisphere radius

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Figure 1 — Microphone array on the hemisphere

Table 1 — Co-ordinates for microphone positions

Microphone position	x/r	y/r	z
1	0,7	0,7	1,5 m
2	-0,7	0,7	1,5 m
3	-0,7	-0,7	1,5 m
4	0,7	-0,7	1,5 m
5	-0,27	0,65	0,71 r
6	0,27	-0,65	0,71 r

6.3 Positioning the machine

6.3.1 All machines, except those with slewing upper structure

The machine centre point shall be approximately vertical above the hemisphere centre point, which is the intersection of the x - and y -axes shown in Figure 1. The front of the machine shall face microphone positions 1 and 4. The midpoint of the basic length, l (see Annex A), is the machine centre point for positioning purposes.

6.3.2 Machines with slewing upper structure

The machine centre point shall be approximately vertical above the hemisphere centre point, which is the intersection of the x - and y -axes shown in Figure 1. The front of the machine shall face microphone positions 1 and 4. The centre of rotation of the upper structure is the machine centre point for positioning purposes.

6.4 Measurement time

The total measurement time for each reading at each measurement position in a stabilized operating mode shall be in the range of 15 s to 30 s.

7 Setting-up and operation of machinery

7.1 General

7.1.1 Safety and operation

All relevant safety precautions and the manufacturer's operating instructions shall be followed during the test.

7.1.2 Machine set-up

The machine shall be equipped with the equipment and attachment(s) specified by the manufacturer. The engine and hydraulic system shall be warmed to normal operating conditions as specified by the machine manufacturer.

All liquid systems shall be filled within the range specified by the manufacturer.

The machine shall be placed on the test site with the attachments positioned at a height of $300 \text{ mm} \pm 50 \text{ mm}$ above the ground or at their maximum height, if this is less than 250 mm. The plane formed by the edges of the attachment shall be approximately parallel to the ground (transport position).

7.1.3 Machine operation conditions

The machine shall be stationary and the brakes applied. The engine shall be operated in a no-load condition at the manufacturer's specified speed corresponding to the engine net power in accordance with ISO 9249. The transmission shall be in neutral, and auxiliary or prime attachments shall not be in operation. Test data shall not be taken until a stabilized operating temperature for the prevailing ambient conditions has been attained. The operator shall remain at the machine controls throughout the test.

7.2 Engine speed

The engine shall be brought first to a low idle condition and then up to the manufacturer's specified rated speed at a stabilized no-load condition prior to each data-taking sequence.

7.3 Fan speed

If the engine of the machine or its hydraulic system is fitted with fan(s), they shall operate during the test. The fan speed shall be in accordance with one of the following conditions, stated and set by the manufacturer of the machine.

a) Fan drive directly connected to the engine

If the fan drive is directly connected to the engine and/or hydraulic equipment (e.g. by belt drive), it shall operate during the test.