
**Acoustics — Measurement at the operator's
position of noise emitted by earth-moving
machinery — Stationary test conditions**

*Acoustique — Mesurage du bruit émis par les engins de terrassement
au poste de conduite — Conditions d'essai statiques*



Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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.

International Standard ISO 6394 was prepared by Technical Committee ISO/TC 43, *Acoustics*, Subcommittee SC 1, *Noise*, in collaboration with ISO/TC 127, *Earth moving machinery*.

This second edition cancels and replaces the first edition (ISO 6394:1985), which has been technically revised.

Annex A forms a normative part of this International Standard.

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Introduction

This International Standard is a special test code for specific types of earth-moving machinery. It is an extension of ISO 11201 which contains the general requirements for many types of machinery and equipment.

Specific procedures are described in this special test code to enable the sound pressure level at the operator's position, with the machine stationary, to be determined in a manner which is repeatable. Attachments (bucket, dozer, etc.) for the manufacturer's production version are 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.

An additional special test code is given in ISO 6393. This other special test code is intended to be used to determine the exterior noise emitted by earth-moving machinery while the machine is stationary, in terms of the A-weighted sound pressure level.

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

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Acoustics — Measurement at the operator's position of noise emitted by earth-moving machinery — Stationary test conditions

1 Scope

This International Standard specifies a method for determining the noise emitted by earth-moving machinery, measured at the operator's position, in terms of the time-averaged A-weighted sound pressure level while the machine is stationary with the engine operating at rated speed under no-load conditions.

This International Standard is applicable to the following specific types of earth-moving machinery:

- excavators (hydraulic or rope-operated);
- crawler and wheel tractor-dozers;
- crawler and wheel loaders; and
- backhoe loaders (also known as excavator loaders).

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3411, *Earth-moving machinery — Human physical dimensions of operators and minimum operator space envelope*.

ISO 6393, *Acoustics — Measurement of exterior noise emitted by earth-moving machinery — Stationary test conditions*.

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

ISO 11201, *Acoustics — Noise emitted by machinery and equipment — Measurement of emission sound pressure levels at a work station and at other specified positions — Engineering method in an essentially free field over a reflecting plane*.

IEC 60651, *Sound level meters*.¹⁾

IEC 60804, *Integrating-averaging sound level meters*.¹⁾

¹⁾ IEC 60651 and IEC 60804 will be replaced by IEC 61672.

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 11201 and the following apply. For the convenience of users of this International Standard, some definitions are quoted from ISO 6165:1997.

3.1

time-averaged A-weighted sound pressure level, $L_{pAeq,T}$

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

3.2

excavator

self-propelled machine on crawler, wheels or legs, having an upper structure normally capable of a 360° swing with mounted equipment, primarily designed for excavating with a bucket, without moving the undercarriage during the work cycle

NOTE An excavator work cycle normally comprises excavating, elevating, swinging and discharging material.

[ISO 6165:1997]

See Figure 1.

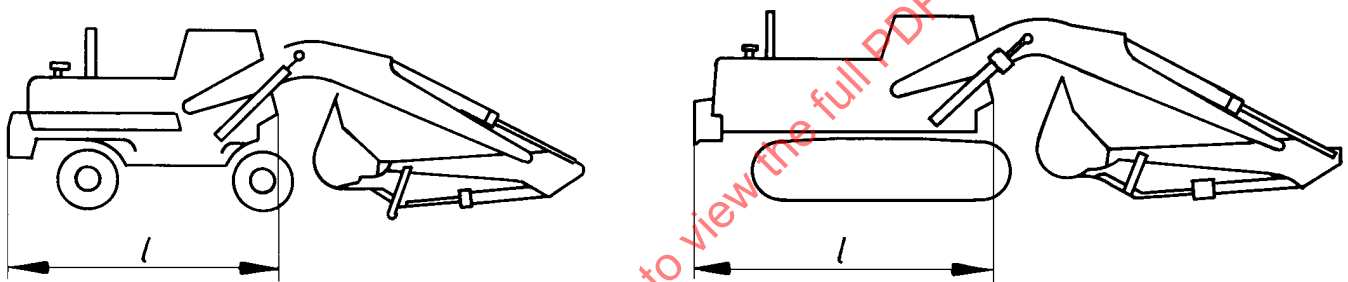


Figure 1 — Excavator

3.3

tractor-dozer

self-propelled crawler or wheeled machine with equipment having either a dozing attachment which cuts, moves and grades material through forward motion of the machine, or a mounted attachment used to exert a push or a pull force

[ISO 6165:1997]

See Figure 2.

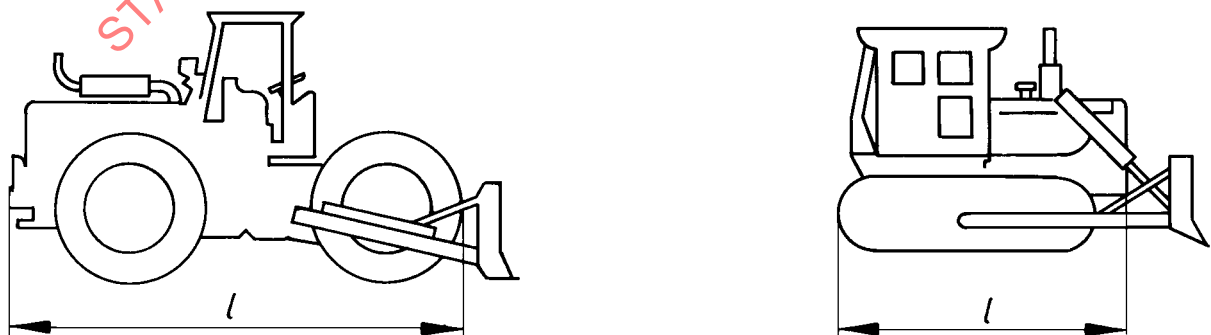


Figure 2 — Tractor-dozer

3.4

loader

self-propelled crawler or wheeled machine, having front-mounted equipment primarily designed for loading operation (bucket use), which loads or excavates through forward motion of the machine

NOTE A loader work cycle normally comprises filling, elevating, transporting and discharging material.

[ISO 6165:1997]

See Figure 3.

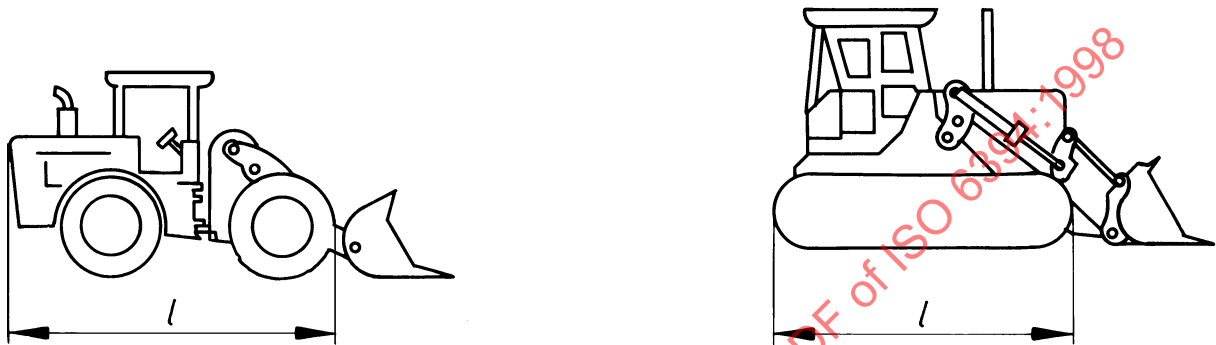


Figure 3 — Loader

3.5

backhoe loader

self-propelled crawler or wheeled machine, having a main frame designed to carry both front-mounted equipment and rear-mounted backhoe equipment (normally with outriggers); when used in the backhoe mode, the machine is stationary and normally digs below ground level; when used in the loader mode (bucket use), the machine loads through forward motion

NOTE A backhoe work cycle normally comprises excavating, elevating, swinging and discharging material. A loader work cycle normally comprises filling, elevating, transporting and discharging material.

[ISO 6165:1997]

See Figure 4.

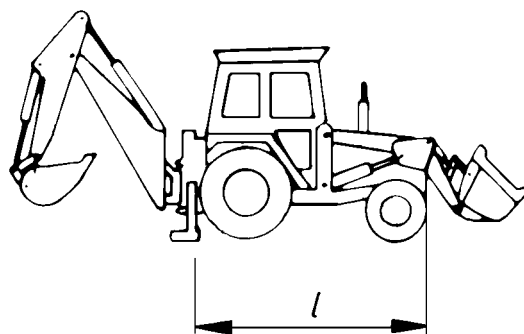


Figure 4 — Backhoe loader

4 Instrumentation

The instrumentation shall be capable of carrying out measurements as described in 8.1. The preferred instrumentation system for acquiring the data is an integrating-averaging sound level meter complying with the

requirements of IEC 60804 for a class 1 instrument. Alternative instrumentation, including the microphone and cable, shall meet the requirements of IEC 60651 for a class 1 instrument.

NOTE The sensitivity to environmental conditions is especially relevant for this type of measurement. It is recommended to ask the manufacturer for evidence that related tests according to IEC 60651 were carried out with a positive result.

5 Test environment

For the purposes of this International Standard, the test environment specified in ISO 6393 applies.

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

6.1 Operator

6.1.1 Operator presence

The operator shall be in the driving position and observers shall not be in close proximity or in the cab during measurements. The operator shall neither wear abnormally sound-absorptive clothing nor any hat or scarf (other than a protective helmet used for safety reasons, or a helmet or frame used to support a microphone) which might influence the noise measurements.

6.1.2 Operator stature

The operator shall have a sitting height between 800 mm (small operator) and 960 mm (large operator) measured from the sitting surface to the top of the head, as specified in ISO 3411.

6.2 Seat adjustment

The seat shall be set at, or as near as possible to, the midpoint of its horizontal and vertical adjustment. Any seat suspension shall be depressed until the seat reaches the midpoint of its dynamic range.

6.3 Microphone

6.3.1 Microphone orientation

The microphone shall be oriented horizontally with its reference direction, as specified by the microphone manufacturer, pointing in the direction in which a person occupying the operator's seat would normally look.

6.3.2 Microphone position

The microphone shall be located $200 \text{ mm} \pm 20 \text{ mm}$ from the median plane of the head and in line with the eyes and to the side of the head where the time-averaged A-weighted sound pressure level is highest.

6.3.3 Microphone mounting

The microphone can conveniently be mounted on a frame or on the helmet, or on a shoulder harness worn by the operator.

6.3.4 Microphone vibration precautions

Care shall be taken to isolate the microphone from vibrations which could affect the measurements. If the microphone is moved during the measurements, care shall be exercised to avoid introducing acoustical noise (for example, noise due to the microphone rubbing against the operator's clothing) or electrical noise (for example, due to a flexing cable) that could interfere with the measurements.

6.3.5 Precautions against microphone reflected noise

6.3.5.1 Care shall be taken to minimize the effect of reflected noise which could affect microphone measurements. Although not a mandatory requirement, the recommendations given in 6.3.5.2 and 6.3.5.3 will minimize the effect of reflected noise.

6.3.5.2 After determining the microphone location, maintain a positional tolerance of ± 50 mm from this location in any direction during the test.

6.3.5.3 Place the microphone a minimum of 100 mm from the side of the head and a minimum of 50 mm above the clothing on the shoulder during the test.

6.4 Positioning of the machine

The machine shall be positioned at the centre of the test site surface.

6.5 Measurement time

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

7 Setting-up and operation of machinery, and setting-up of operator's position (see annex A)

7.1 Machine operating sequence

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.

7.2 Setting-up of operator's position when the machine is equipped with a cab

7.2.1 Cab with air-conditioning and/or ventilating system(s)

Measurements shall be taken with the doors and windows closed and the air-conditioning and/or ventilating system(s) operating at midrange speed if more than two operating speeds are available. If only two operating speeds are available, then the highest speed shall be used. If the air-conditioning and/or ventilating systems have a recirculate and outside air position control, the control shall be set for outside air.

7.2.2 Cab with no air-conditioning or ventilating system(s)

Measurements shall be taken with the doors and windows closed and repeated with the doors and windows open. The higher measurement result from the two sets of data obtained shall be used as the reported value.

8 Acoustic measurements

8.1 Quantities to be measured

The time-averaged A-weighted sound pressure level, $L_{pAeq,T}$, in decibels, is determined either by using equation (1) or by using a digital integration [equation (2)].

$$L_{pAeq,T} = 10 \lg \left[\frac{1}{T} \int_0^T \frac{p_A^2(t)}{p_0^2} dt \right] \text{ dB} \quad \dots (1)$$

where

T is the measurement period, i.e. the period of time for which the machine is operated during the test;

$p_A(t)$ is the instantaneous A-weighted sound pressure of the sound signal;

p_0 is the reference sound pressure (20 μPa).

$$L_{pAeq,T} = 10 \lg \left[\sum_{i=1}^n \frac{t_i}{100} 10^{0,1L_{pAi}} \right] \text{ dB} \quad \dots (2)$$

where

t_i is the numerical value of the percentage of time for the sound pressure level, L_{pAi} , from the whole time interval, T , of the test, with the cell width for L_{pAi} being 1,0 dB or less;

L_{pAi} are the values of A-weighted sound pressure levels obtained with instrumentation complying with the requirements of IEC 60651 for a class 1 instrument and set for the time-weighting characteristics.

8.2 Number of measurements

A minimum of three measurements at the microphone position shall be required. It is necessary to have two of the readings at the microphone position within a 1 dB range of each other. If these results are not obtainable, additional readings shall be taken to meet this requirement.

9 Determination of measurement result

The reported value of the time-averaged A-weighted sound pressure level will be the arithmetic mean of the two highest values that are within a 1 dB range of each other.

10 Information to be recorded

The following information, whenever applicable, shall be compiled and recorded for all measurements made in accordance with the requirements of this International Standard.

10.1 Machinery under test

- Machine manufacturer.
- Machine model number.
- Serial number.
- Machine arrangement, including major attachments and the manufacturer's specified rated speed which is the speed at which the engine develops rated power in accordance with ISO 9249.

10.2 Acoustic environment

- Description of the test site and the type of test site surface or surfaces used, including a sketch showing the position of the machine.
- Air temperature, barometric pressure, relative humidity and wind velocity at the test site.

10.3 Instrumentation

- Equipment used for the acoustical measurements, including name, type, serial number and manufacturer.
- Method used to calibrate the instrumentation system.
- Date and place of calibration of the sound calibrator and the instrumentation system.

10.4 Acoustical data

- a) Location of the microphone.
- b) Time-averaged A-weighted sound pressure level at the microphone position for each measurement conducted in accordance with 8.2.
- c) Time-averaged A-weighted sound pressure level of the background noise at the microphone position.
- d) Reported value of the time-averaged A-weighted sound pressure level in accordance with clause 9.

11 Information to be reported

- a) Time-averaged A-weighted sound pressure level from clause 9, rounded to the nearest whole number ($< 0,5$, use lower number; $\geq 0,5$, use higher number) for the configuration or configurations of operator's position depending on how the machine is equipped.
- b) Machine manufacturer, model number, serial number, net power, in kilowatts, as defined in ISO 9249, machine arrangement, including major attachments and the type of test site surface or surfaces used.
- c) Manufacturer's specified rated speed, which is the speed at which the engine develops rated power in accordance with ISO 9249.

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