TC 43

International Standard 6393

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Acoustics — Measurement of airborne noise emitted by earth-moving machinery — Method for determining compliance with limits for exterior noise — Stationary test condition

Acoustique — Mesurage du bruit aérien émis par les engins de terrassement — Méthode de vérification de la conformité en ce qui concerne les limites de bruit extérieur — Condition d'essai statique

First edition — 1985-05-15

UDC 534.6 : 621.878/.879 **Ref. No. ISO 6393-1985 (E)**

Descriptors : acoustics, earth moving equipment, tests, acoustic tests, static tests, determination, noise (sound), sound pressure, sound power.

Price based on 7 pages

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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 6393 was prepared by Technical Committee ISO/TC 43, *Acoustics* and ISO/TC 127, *Earth-moving machinery*.

Printed in Switzerland

Acoustics — Measurement of airborne noise emitted by earth-moving machinery — Method for determining compliance with limits for exterior noise — Stationary test condition

0 Introduction

This International Standard is a special test code for specific types of earth-moving machinery. It is an extension of ISO 4872 which contains the general requirements for construction equipment.

Specific requirements are provided in this special test code to enable the sound power emission in a stationary test condition to be determined in a manner which is repeatable. Attachments (bucket, dozer, etc.) for the manufacturer's production version shall be fitted since this is the configuration most likely to exist when the machine is in actual use.

This International Standard will enable 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 6394. This other special test code shall be used to determine the noise emitted by earth-moving machinery, with the machine in a stationary condition, measured at the operator's position in terms of the equivalent continuous A-weighted sound pressure level.

1 Scope

This International Standard describes a method for determining the exterior noise emitted by earth-moving machinery in terms of the A-weighted sound power level while the machine is in a stationary test condition. At six positions on a hemispherical surface, the equivalent continuous A-weighted sound pressure levels are measured. The A-weighted sound power level of the machinery is calculated from the measured values.

2 Field of application

This International Standard is applicable to the following specific types of earth-moving machinery (see also the annex): excavators (hydraulic or rope operated), crawler and wheel tractors with dozer equipment, and crawler and wheel loaders.

3 References

ISO 1585, *Road vehicles — Engines test code — Net power.*

ISO 4872, *Acoustics — Measurement of airborne noise emitted by construction equipment intended for outdoor use — Method for determining compliance with noise limits.*

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary.*

ISO 6394, *Acoustics — Measurement of airborne noise emitted by earth-moving machinery — Operator's position — Stationary test condition.*

IEC Publication 651, *Sound level meters.*

4 Definitions

For the purposes of this International Standard, the definitions given in ISO 4872 and the following definitions apply.

4.1 equivalent continuous A-weighted sound pressure level, $L_{pAeq,T}$: The A-weighted sound pressure level averaged on an energy basis over the whole measurement period.

4.2 A-weighted sound power level, L_{WA}: The A-weighted sound power level using equivalent continuous A-weighted sound pressure levels averaged over the measurement surface and averaged on an energy basis over the whole measurement period.

5 Instrumentation

5.1 General

For the purposes of this International Standard, the instrumentation specified in ISO 4872 applies. An additional requirement relating to the microphone is given in 5.2.

5.2 Microphone

A condenser microphone or the equivalent in accuracy, stability and frequency response shall be used. The external diameter of the microphone shall not exceed 13 mm so as to reduce possible directivity errors. The microphone and its associated cable shall be chosen so that the combined sensitivity does not change significantly over the temperature range encountered during the measurements.

6 Test environment

6.1 General

For the purposes of this International Standard, the test environment specified in ISO 4872, clause 4 and annex A, applies. Additional requirements are given in 6.2 to 6.6.

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

6.2 Test site and environmental correction, K

For test sites which consist of a hard, flat ground surface, such as asphalt or concrete, and with no sound-reflecting obstacles within a distance from the source equal to three times the greatest distance from the source centre to the lower measurement positions, it may be assumed that the environmental correction, K, is less than or equal to 0,5 dB and is, therefore, negligible and can be disregarded.

6.3 Test site surface

Three types of test site surface are allowed. The choice is optional and the test site surface or surfaces selected shall be reported as specified in clauses 11 and 12. The test site surfaces are outlined in 6.3.1 to 6.3.3.

6.3.1 Hard reflecting plane (Test site surface A)

The test area bordered by the microphones shall consist of concrete or sealed asphalt that has not incurred any extensive surface deterioration.

6.3.2 Sand (Test site surface B)

The test area bordered by the microphones shall consist of humid sand of grain size up to 2 mm. The minimum depth of the sand shall be 0,3 m for the working location of the machine. The remainder of the test site should have a minimum depth of 0,05 m. If 0,3 m is not sufficient depth for track penetration, the depth shall be increased accordingly.

6.3.3 Compacted earth (Test site surface C)

The test area bordered by the microphones shall consist of compacted earth that is slightly moist and will permit track or wheel lug penetration. The moisture content shall be low enough so that the material does not stick or pack in the track system or in the wheel lugs. The material shall be free of stones greater than 25 mm in diameter and the proportion of sand, gravel or crushed rock should not exceed 50 %. The soil may be clay or loam.

6.4 Background noise

Background noise at each measurement position shall be at least 10 dB lower than the noise emitted by the machine.

6.5 Climatic conditions

When precipitation, i.e. rain, snow or hail, is falling or when the ground surface is covered with snow, it is recommended that measurements should not be carried out.

6.6 Signal devices

Any signal devices, such as forward warning horn or back-up alarm, shall not be activated during this test.

7 Measurement of equivalent continuous A-weighted sound pressure levels

7.1 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 (see figures 1, 2 and 3). The basic length encloses the main body of the machine and excludes major attachments, such as dozer blades, buckets 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 1,5 m but less than 4 m;

— 16 m when the basic length, L, of the machine to be tested is greater than 4 m.

7.2 Microphone positions on the hemispherical measurement surface

There shall be six measurement positions, i.e. positions 2, 4, 6, 8, 10 and 12, arranged as defined in 7.2.3, alternative B, of ISO 4872. The microphone array and coordinates shall be as shown in figure 4.

7.3 Positioning of the machine

7.3.1 Loaders and tractors with dozer equipment

The machine centreline shall coincide with the hemisphere centreline which is the intersection of the x- and y-axes in figure 4. The front of the machine shall face microphone

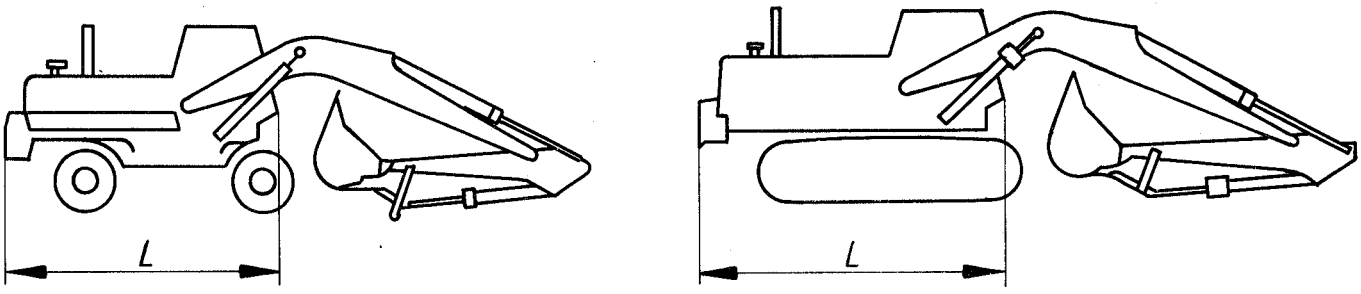


Figure 1 — Excavator

Figure 2 — Tractor with dozer equipment

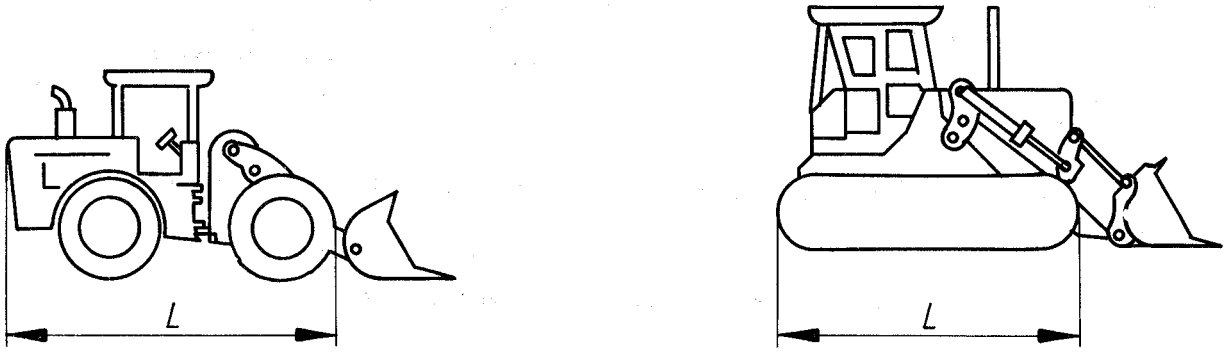
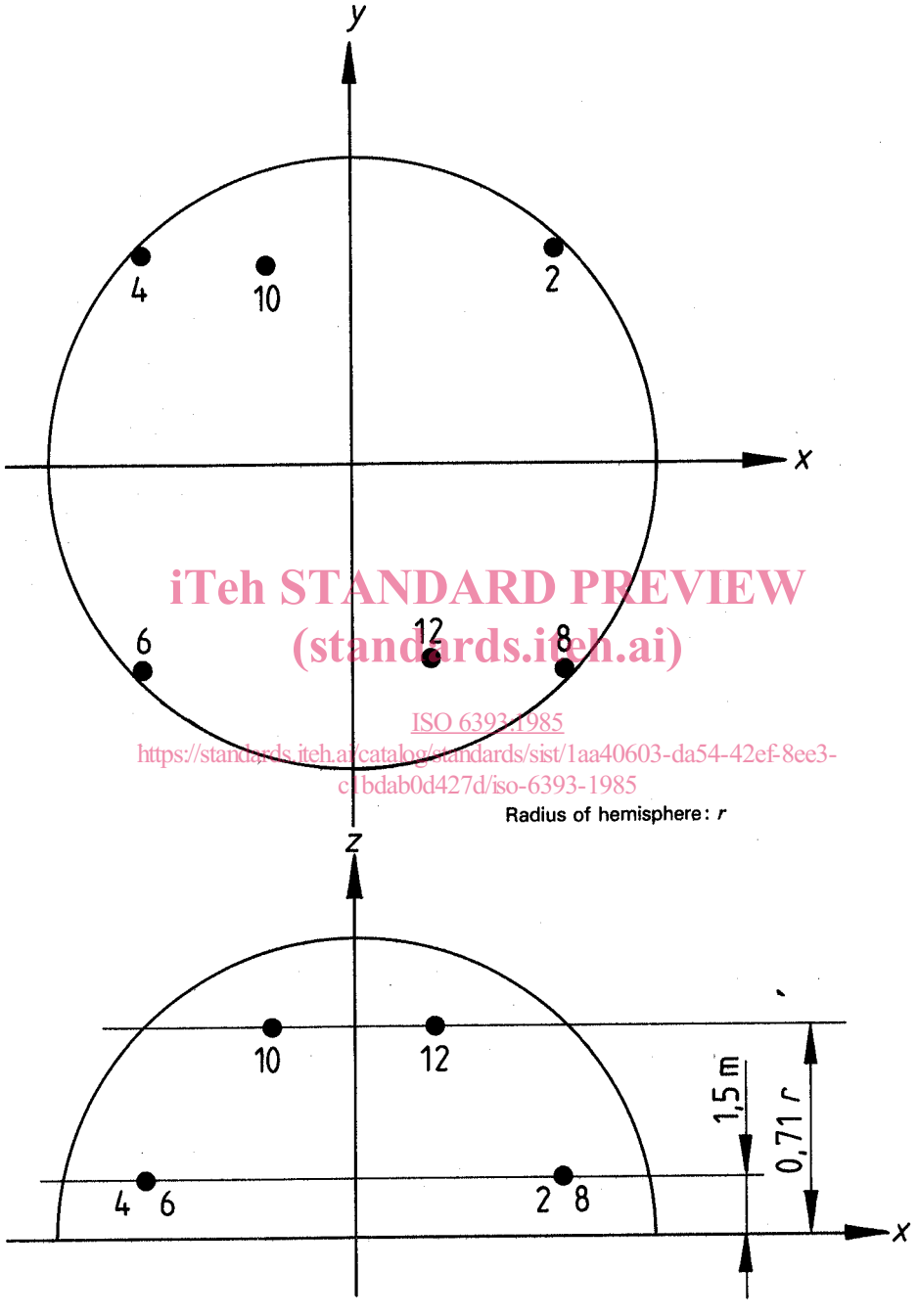


Figure 3 — Loader



Radius of hemisphere: r

NOTE — For the coordinates of the six measurement positions, see ISO 4872, table 2 (alternative B).

Figure 4 — Microphone array on the hemisphere

positions Nos. 2 and 8. The mid-point of the basic length L (see figures 2 and 3) is defined as the machine centreline for positioning purposes.

7.3.2 Excavators

The machine centreline shall coincide with the hemisphere centreline which is the intersection of the x- and y-axes in figure 4. The front of the machine shall face microphone positions Nos. 2 and 8. The centre of rotation of the upper structure of the excavator (see figure 1) is defined as the machine centreline for positioning purposes.

7.4 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 to 30 s.

8 Definitions, setting-up and operation of machinery

8.1 Definitions, setting-up and operation

See the annex.

8.2 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.

9 Acoustic measurements

9.1 Measuring instrumentation

The preferred instrumentation system for acquiring the data shall be one that determines the equivalent continuous A-weighted sound pressure level with characteristics that will permit it to qualify for at least a type 1 accuracy in accordance with IEC Publication 651. The equivalent continuous A-weighted sound pressure level, $L_{pAeq,T}$, in decibels, shall be determined using the following equation:

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

where

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

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

$p_0(t)$ is the reference sound pressure (= 20 µPa).

Alternatively, digital integration may be used to determine $L_{pAeq,T}$, in decibels, using the following equation:

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

where $\frac{t_i}{100}$ 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.

NOTE — If a non-integrating sound level meter, type 1, is used, no reference to equivalent continuous type data can be made in all the recorded and reported information.

9.2 Number of measurements

A minimum of three measurement series at all microphone positions shall be required. In order to meet the requirements laid down in 10.3, additional measurement series may be necessary.

10 Calculation of A-weighted sound power level using equivalent continuous A-weighted sound pressure levels averaged over the measurement surface

10.1 Calculation of equivalent continuous A-weighted sound pressure level averaged over the measurement surface, $\overline{L_{pAeq,T}}$

The equivalent continuous A-weighted sound pressure level averaged over the measurement surface, $\overline{L_{pAeq,T}}$, in decibels, (reference: 20 µPa), shall be calculated from the measured values of the equivalent continuous A-weighted sound pressure levels by means of the following equation:

$$\overline{L_{pAeq,T}} = 10 \lg \left[\frac{1}{N} \sum_{i=1}^{N} 10^{0,1 L_{pAeqi}} \right] \qquad \ldots (3)$$

where

L_{pAeqi} is the equivalent continuous A-weighted sound pressure level resulting from the ith microphone position, corrected for background noise, in decibels. Reference: 20 µPa;

N is the total number of microphone positions.

10.2 Calculation of A-weighted sound power level

The A-weighted sound power level, L_{WA}, in decibels, of the machinery shall be calculated using the following equation:

$$L_{WA} = (\overline{L_{pAeq,T}} - K) + 10 \lg \frac{S}{S_0} \quad \ldots (4)$$

where

S is the area of the measurement surface, in square metres (for a hemispherical measurement surface, $S = 2\pi r^2$);

$S_0 = 1\ m^2$;

$10 \lg \frac{S}{S_0} = 20$ for 4 m radius, 28 for 10 m radius and 32 for 16 m radius;

K is the environmental correction, in decibels (see annex A of ISO 4872 and 6.2 of this International Standard).

10.3 Determination of measurement result

Calculate at least three values of the sound power level from the three sets of data obtained at all microphone positions (see 9.2). It is necessary to have two of these values within a 1 dB range of each other. The reported value of the A-weighted sound power level will be the arithmetic mean of the two highest values that are within a 1 dB range of each other.

11 Information to be recorded

11.1 Machinery under test

a) The machine manufacturer.

b) The machine model number.

c) The serial number.

d) The 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 1585.

11.2 Acoustic environment

a) A description of the test site and the type of test site surface or surfaces used, including a sketch showing the position of the machine.

b) The air temperature, barometric pressure, relative humidity and wind velocity at the test site.

11.3 Instrumentation

a) The instrumentation used for the measurements, including name, type, serial number and manufacturer.

b) The method used to calibrate the instrumentation system.

c) The date and place of calibration of the acoustical calibrator.

11.4 Acoustical data

a) The location of the microphones.

b) The equivalent continuous A-weighted sound pressure level at each microphone position for each measurement conducted in accordance with 9.1.

c) The A-weighted sound pressure level of the background noise at each microphone position. All intermediate results, such as sound pressure and area calculation, shall be expressed to one decimal point.

d) The equivalent continuous A-weighted sound pressure level averaged over the measurement surface, calculated in accordance with 10.1.

e) The A-weighted sound power level calculated in accordance with 10.2.

12 Information to be reported

a) The calculated A-weighted sound power level, calculated in accordance with 10.2, rounded to the nearest whole number ($< 0{,}5$, use lower number; $\geqslant 0{,}5$ use higher number).

b) The machine manufacturer, model number, serial number, net power, in kilowatts, as defined in ISO 1585, machine arrangement, including major attachments and the type of test site surface or surfaces used.

c) The manufacturer's specified rated speed which is the speed at which the engine develops rated power in accordance with ISO 1585.