

Methods for

Measurement of whole-body vibration of the operators of agricultural wheeled tractors and machinery

[ISO title: Agricultural wheeled tractors and field machinery —
Measurement of whole-body vibration of the operator]

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The Agricultural Machinery and Implements Standards Committee, under whose direction this British Standard was prepared, consists of representatives from the following:

- Agricultural Engineers' Association*
- Agricultural Machine Parts Export Association
- British Agricultural and Garden Machinery Association Limited*
- British Lawn Mower Manufacturers' Federation
- Department of Industry (Mechanical Engineering)*
- Health and Safety Executive*
- Institution of Agricultural Engineers Incorporated
- Ministry of Agriculture, Fisheries and Food*
- National Farmers' Union*
- National Institute of Agricultural Engineering*
- Royal Welsh Agricultural Society

The organizations marked with an asterisk in the above list, together with the following, were directly represented on the Technical Committee entrusted with the preparation of this British Standard:

- County Surveyors' Society
- Forestry Commission
- Society of Motor Manufacturers and Traders Limited
- Individual experts

This British Standard, having been prepared under the direction of the Agricultural Machinery and Implements Standards Committee, was published under the authority of the Executive Board and comes into effect on 27 February 1981

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National foreword

This British Standard has been prepared under the direction of the Agricultural Machinery and Implements Standards Committee and is identical with ISO 5008:1979 “*Agricultural wheeled tractors and field machinery — Measurement of whole-body vibration of the operator*”, incorporating the erratum dated 1 June 1980, prepared by Technical Committee ISO/TC 23, Tractors and machinery for agriculture and forestry, of the International Organization for Standardization (ISO).

Terminology and conventions. The text of the International Standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is especially drawn to the following.

The comma has been used throughout as a decimal marker. In British Standards it is current practice to use a full point on the baseline as the decimal marker.

Wherever the words “International Standard” appear, referring to this standard, they should be read as “British Standard”.

Cross-references. There are no corresponding British Standards for the following international publications referred to in the text: IEC Publication 225:1966, ISO 2041:1975, ISO 2631:1978 and ISO/TR 5007. The technical committee has reviewed the provisions of these international publications and has decided that they are acceptable for use in conjunction with this standard.

Related British Standards for IEC Publication 225:1966, ISO 2041:1975 and ISO 2631:1978 are BS 2475:1964 “*Octave and one third octave band-pass filters*”, BS 3015:1976 “*Glossary of terms relating to mechanical vibration and shock*” and DD 32:1974 “*Guide to the evaluation of human exposure to whole-body vibration*” respectively.

Since ISO/TR 5007 has now been published footnote 1) to clause 2 is no longer appropriate. The reference to ISO/TR 5007 in the note to clause 1 is of an informative nature only and the lack of an equivalent British Standard at present does not, therefore, affect the validity of this standard. However, it is intended that ISO/TR 5007 will be implemented as a British Standard in due course.

NOTE *Textual error.* When incorporating the erratum dated 1 June 1980, the following error was noticed. It has been corrected in this British Standard and has been reported to ISO/TC 23 in a proposal to amend the text of the International Standard.

In paragraph 1 of 8.1, “track wheel setting” has been deleted and replaced by “wheel track setting”.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 12, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

0 Introduction

The specification of instruments, measurement site characteristics and frequency analysis of weighting allows the measurements to be made and reported with an acceptable precision.

The vibration is evaluated in accordance with ISO 2631. The procedure includes means of weighting the vibration level at different frequencies to take account of agreed approximations to the frequency sensitivity of the human operator.

1 Scope and field of application

This International Standard specifies methods for measuring and reporting the whole-body vibration to which the operator of an agricultural wheeled tractor or other field machine is exposed.

The operating conditions of the machine and the ordinates of optional artificial test tracks are also included.

This International Standard applies when measurements are made under field conditions or where artificial surfaces are used for the comparison of different models of particular machines.

It is recognized that there may be designs of tractor for which this International Standard is not appropriate, for example stilt-tractors, tricycle tractors, hillside tractors or vineyard tractors etc.

NOTE The standard does not include assessment of vibration reaching the operator other than through his seat or foot platform; for example, that sensed by the feet through the controls or by the hands through the steering wheel is not considered. ISO/TR 5007 specifies measurement of transmitted vibration and seat dimensions for operator's seats for agricultural tractors.

2 References

ISO 2041, *Vibration and shock — Vocabulary*.

ISO 2631, *Guide for the evaluation of human exposure to whole-body vibration*.

ISO/TR 5007, *Agricultural wheeled tractors — Operator seat — Measurement of transmitted vibration and seat dimensions*¹⁾.

IEC Publication 225, *Octave, half-octave and third octave band filters intended for the analysis of sounds and vibrations*.

3 Definition

For the purposes of this International Standard, the following definition shall supplement those of ISO 2041:

3.1

weighted vibration

the measured vibration acceleration modified by the frequency-weighting defined below

4 Vibration measurement axes

The vibration shall be measured along three mutually perpendicular axes passing through a point on the interface between the operator and his seat. These axes are vertical, longitudinal and lateral (a_z , a_x and a_y) with respect to the tractor.

These axes correspond in their orientation with the similar axes (a_z , a_x and a_y) for the operator, when the operator is at his work-place, and are defined in detail in ISO 2631.

5 Instruments

5.1 Vibration transducers and amplifiers

The vibration shall be sensed by acceleration transducers (accelerometers) attached to the rigid part of a disc of 250 ± 50 mm diameter of which the centre part shall be rigid up to a diameter of 75 mm (a typical arrangement is shown in Figure 1). The transducer should preferably be protected by a rigid cover. The disc, which may be covered with a 20 mm thick resilient material, shall be placed between the operator and the centre of his seat. Where the operator is standing, the transducers shall be rigidly attached to the foot platform as near as possible to his feet.

The transducers together with their associated amplifiers shall be sensitive to vibration levels of $0,05 \text{ m/s}^2$ and shall be capable of measuring vibrations of 5 m/s^2 r.m.s. with a crest factor (ratio of peak to r.m.s. value) as great as 3 without distortion and with an accuracy of $\pm 0,05 \text{ m/s}^2$. Frequency response shall not vary in the range 1 to 80 Hz by more than 5 %.

5.2 Recording equipment

The electrical signals generated by the transducers may be recorded for later analysis on magnetic tape or other recording equipment.

¹⁾ At present at the stage of draft.

The recording equipment shall have a replay accuracy of better than $\pm 3,5\%$ over the frequency range 1 to 80 Hz including any change of tape speed made during replay for the purpose of analysis.

5.3 Frequency weighting

Frequency weighting shall be achieved in either of two ways:

- by analysis of the acceleration into 1/3 octave band levels, weighting the levels in individual bands and re-combination;
- or by direct use of electrical filters in a frequency-weighting “ride meter”.

5.3.1 Frequency analysis method

5.3.1.1 Analyse each vibration tape recording into 1/3 octave component accelerations over the frequency range 1,0 to 80 Hz, the 1/3 octave centre frequencies being in compliance with IEC Publication 225, which shall however, be extrapolated for the lower frequencies.

5.3.1.2 Average the root mean square (r.m.s.) value of each component (b_f) over the duration specified for the measurement.

5.3.1.3 Multiply the 1/3 octave values by the weighing factors (w_f) listed in Table 1, and calculate a weighted acceleration (B_w) value for each recording as the square root of the sum of the squares of the weighted 1/3 octave values:

$$B_w = \sqrt{\sum_{f=1,0}^{80} w_f^2 b_f^2}$$

5.3.2 Frequency-weighting “ride meter”

The “ride meter”, if employed for direct indication of the weighted vibration, shall consist of an electronic weighting network incorporated between the transducer and a time integration stage. The weighting network shall have an insertion loss according to the curve in Figure 2, for vertical vibration, or Figure 3, for horizontal vibration. The loss shall not deviate from the curve by more than 0,5 dB from 2 to 4 Hz for vertical measurement or ± 1 dB at 6,3 Hz vertical measurement and 1,25 Hz horizontal measurement. For any other frequency, vertical or horizontal, ± 2 dB shall apply. The integration stage shall be capable of indicating the integral (I) of the square of weighted vibration acceleration (b_w^2) for the time period of the test run (T), or its square root (I'), i.e.

$$I = \int_0^T b_w^2 dt$$

$$\text{or } I' = \sqrt{\int_0^T b_w^2 dt}$$

or directly the r.m.s. value of the weighted vibration acceleration (A_{weff}):

$$A_{\text{weff}} = \sqrt{\frac{I}{T}} = \frac{\sqrt{I}}{\sqrt{T}}$$

The overall accuracy of the so determined r.m.s. value of the weighted vibration acceleration shall be within $\pm 5\%$.

5.4 Calibration

The entire measurement and analysis equipment shall be regularly calibrated, where possible in accordance with existing standards or recommendations.

Table 1 — Weighting factors relative to the frequency range of maximum acceleration sensitivity (see ISO 2631)

Frequency (centre frequency of 1/3 octave band) Hz	Weighting factor for	
	vertical vibrations (Figure 2)	horizontal vibrations (Figure 3)
1,0	0,50 = - 6 dB	1,00 = 0 dB
1,25	0,56 = - 5 dB	1,00 = 0 dB
1,6	0,63 = - 4 dB	1,00 = 0 dB
2,0	0,71 = - 3 dB	1,00 = 0 dB
2,5	0,80 = - 2 dB	0,80 = - 2 dB
3,15	0,90 = - 1 dB	0,63 = - 4 dB
4,00	1,00 = 0 dB	0,5 = - 6 dB
5,00	1,00 = 0 dB	0,4 = - 8 dB
6,3	1,00 = 0 dB	0,315 = - 10 dB
8,00	1,00 = 0 dB	0,25 = - 12 dB
10,00	0,80 = - 2 dB	0,2 = - 14 dB
12,5	0,63 = - 4 dB	0,16 = - 16 dB
16,0	0,50 = - 6 dB	0,125 = - 18 dB
20,0	0,40 = - 8 dB	0,1 = - 20 dB
25,0	0,315 = - 10 dB	0,08 = - 22 dB
31,5	0,25 = - 12 dB	0,063 = - 24 dB
40,0	0,20 = - 14 dB	0,05 = - 26 dB
50,0	0,16 = - 16 dB	0,04 = - 28 dB
63,0	0,125 = - 18 dB	0,0315 = - 30 dB
80,0	0,10 = - 20 dB	0,025 = - 32 dB