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Agricultural wheeled tractors and field machinery — Measurement of whole-body vibration of the operator

Tracteurs et matériels agricoles à roues — Mesurage des vibrations globales du corps du conducteur

Reference number
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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 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5008 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 2, *Common tests*.

This second edition cancels and replaces the first edition (ISO 5008:1979), which has been technically revised.

Annexes A and B of this International Standard are for information only.

Introduction

The purpose of this International Standard is to define the specification of instruments, measurement procedures, measurement site characteristics and frequency weighting that will allow the whole body vibration of agricultural wheeled tractors and field machinery to be made and reported with acceptable precision.

The vibration is evaluated in accordance with currently accepted standards including means of weighting the vibration levels at different frequencies to take account of the frequency sensitivity of the human operator to whole body vibration.

Agricultural wheeled tractors and field machinery — Measurement of whole-body vibration of the operator

1 Scope

1.1 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 when operating on a standard test track.

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

1.3. This International Standard applies when measurements are made on the artificial test tracks defined herein.

1.4. Measurements made under field conditions are covered in annex A.

1.5. This International Standard does not include assessment of vibration reaching the operator other than through his/her seat or foot platform (e.g., vibration that is sensed by the feet through the controls or by the hands through the steering wheel is not considered).

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 2041:1990, *Vibration and shock — Vocabulary*

ISO 2631-1:1997, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 5007:[1)], *Agricultural wheeled tractors — Operator's seat — Laboratory measurement of transmitted vibration*

ISO 5348:1998, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO 8041:1990, *Human response to vibration — Measuring instrumentation*

ISO 10326-1:1992, *Mechanical vibration — Laboratory method for evaluating vehicle seat vibration — Part 1: Basic requirements*

ISO 13090-1:1998, *Mechanical vibration and shock — Guidance on safety aspects of tests and experiments with people — Part 1: Exposure to whole-body mechanical vibration and repeated shock*

1) To be published. (Revision of ISO 5007:1990)

3 Terms and definitions

For the purposes of this International Standard, the terms and definitions given in ISO 2041 and the following apply.

3.1
whole-body vibration
vibration transmitted to the body as a whole through the buttocks of a seated operator

3.2
operator seat
that portion of the machine provided for the purpose of supporting the buttocks and back of the seated operator, including any suspension system and other mechanisms provided (e.g., for adjusting the seat position)

3.3
frequency analysis
process of arriving at a quantitative description of vibration amplitude as a function of frequency

3.4
measuring period
time duration in which vibration data for analysis is obtained

4 Symbols

$a_{wi}(t)$	frequency weighted acceleration in the direction i (i = x, y or z)
a_{wx}	rms value of the frequency weighted acceleration in the x direction
a_{wy}	rms value of the frequency weighted acceleration in the y direction
a_{wz}	rms value of the frequency weighted acceleration in the z direction
B_e	resolution bandwidth of the frequency analysis, in hertz
D	distance from start, in metres (see clause 11)
L	ordinate of left-hand strip, in millimetres (see clause 11)
rms	root-mean-square
R	ordinate of right-hand strip, in millimetres (see clause 11)
T_s	sampling time, in seconds

5 Vibration measurements

5.1 Location of the measurements

The vibration shall be measured along three mutually perpendicular axes, defined as follows:

x-direction: back to chest

y-direction: right side to left side

z-direction: foot (or buttocks) to head

The vibration shall be determined as close as possible to the point or area through which the vibration is transmitted to the body.

a) In the case where the operator is normally sitting, transducers mounted in a semirigid disc shall be placed on the surface of the seat such that the transducers are located midway between the ischial tuberosities of the seated person. It is acceptable if the centre of the disc is located slightly in front (up to 5 cm) of the ischial turberosities or the vertical projection of the Seat Index Point (SIP).

b) In the case where the operator is normally standing, the transducers shall be located on the platform midway between the arches of the feet.

5.2 Magnitude of vibration

The quantity used to describe the magnitude of vibration shall be the frequency-weighted acceleration in meters per second squared (m/s^2), expressed as a root-mean-square (rms) value.

The frequency weightings to be used are defined in 6.3.

The rms value a_{wi} used in this International Standard is defined as the rms value of the frequency weighted acceleration signal $a_{wi}(t)$ [i = x,y or z]:

$$a_{wi} = \left[\frac{1}{T} \int_0^T a_{wi}^2(t) \mathrm{d}t \right]^{1/2}$$

For tests on a standard track, the integration time shall be the time required to traverse the track.

6 Instrumentation

6.1 General

Measuring equipment may comprise:

a) transducers (usually accelerometers);

b) conditioning amplifiers and filters;

c) telemetry set;

d) recorders (digital or analog);

e) meters.

The dynamic range, sensitivity, accuracy, linearity and overload capacity of the vibration measuring system shall be in accordance with ISO 8041:1990 for type 1 instruments.

6.2 Transducers

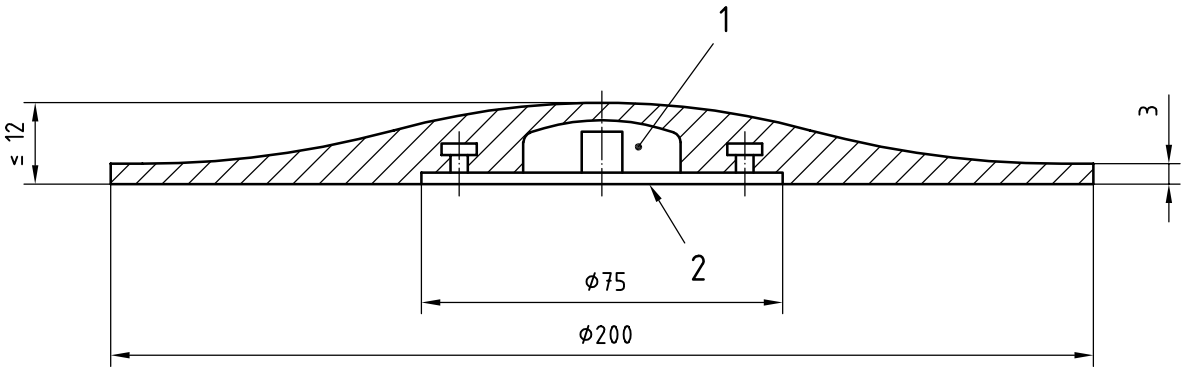
Accelerometers shall normally be used for measurement of vibration. The mounting of accelerometers shall be in accordance with ISO 5348 and the transducer manufacturer's instructions. Transducers oriented in different directions at a single measurement location shall be as close together as possible. Care should be taken to ensure, as far as is practical, that neither the mass of the measuring device and its fixture, nor any local resonances, significantly affect the measured value.

The transducers used for the measurement in the seat shall be mounted in a semirigid disc (see Figure 1). The disc shall be 12 mm or less in thickness and be made of approximately 80-90 Shore-A molded rubber or plastic material.

NOTE For practical reasons it is usually not possible to perfectly align the accelerometers in the disc with the directions of the basicentric coordinate system. In a tolerance range to within ± 15° of the appropriate directions, the accelerometers may be considered as aligned parallel to these directions.

The transducers used for the measurement at the feet of a standing operator shall be rigidly fixed (e.g. by screwing or glueing) on to the working platform. If the working platform is covered by a resilient material, the transducers may be mounted in the middle of a rigid metal plate (about 30 cm × 40 cm) with the operator standing on the plate.

Dimensions in millimetres



Key

1 Cavity appropriate for accelerometers

2 Thin metal disc for accelerometer mount and added centre rigidity

Figure 1 — Design for semirigid disc for seat accelerometers
(see ISO 10326-1)

6.3 Frequency weighting

The frequency weightings to be used shall correspond to frequency weightings W_d (for the x and y directions) and W_k (for the z direction) in accordance with ISO 2631-1:1997 for whole body vibration.

6.4 Calibration

The whole measurement chain shall be checked both before and after a sequence of measurements by using a calibration source that produces a known acceleration at a known frequency.

NOTE It is also important to regularly check that the whole chain is also calibrated at other frequencies throughout the frequency range of interest.

In addition to regular preventive calibration (e.g. every two years), calibration is also necessary after rough handling of any important part of the measurement chain. The results of the calibration check shall be recorded.

7 Safety recommendations

Safety precautions shall be in accordance with ISO 13090-1.

8 Operator

If the tractor fits one of the 3 tractor classes that are defined in ISO 5007 and is equipped with a seat for which the SEAT factor has been established for that class, the test can be made with one operator weighing 75 kg ± 5 kg.

If the tractor does not fit one of the 3 tractor classes that are defined in ISO 5007 and/or the SEAT factor for the seat has not been established, the test shall be made with both a light and a heavy operator. The light person shall have a total mass of 52 kg to 55 kg, of which not more than 5 kg may be carried in a belt around the waist. The heavy person shall have a total mass of 98 kg to 103 kg, of which not more than 8 kg may be carried in a belt around the waist.

9 Operator seat

9.1 General

The operator seat for the test shall be representative of series-produced models, with regard to construction, static and vibration characteristics and other features that may affect the vibration test result.

Any compliant end-stops or devices normally fitted to production versions of the seat to be tested to minimize the effect of suspension over-travel shall be in place for the tests.

9.2 Run-in

Before the test, the suspension seats shall be run-in for a minimum of 1 h of operation under typical working conditions.

9.3 Seat adjustment

The seat shall be adjusted to the weight of the test person in accordance with the manufacturer's instructions.

For seats with adjustable damping, the damper shall be set according to the manufacturer’s instructions.

For seats with fore-aft and/or lateral isolation, such isolation shall be working.

The other seat adjustments shall be made to suit the operator.

10 Condition of tractor

The tractor may be with or without a safety frame or cab, however, a ROPS structure and the use of a seat belt are highly recommended. For normal measurements, the tractor shall be in working order with full fuel tank and radiator, but without optional front and rear weights, tyre ballast, mounted implements and equipment and any specialized components. The tyres used in the test shall be the standard size for the tractor, as specified by the manufacturer. The depth of the tread shall be not less than 65 % of the depth of a new tread. The tyre walls shall not be damaged and the tyre pressures shall be the arithmetic mean of the ranges recommended by the manufacturer. The tyres shall be warmed up by traversing the test course at least × 2 immediately prior to the start of the test runs. Tyre pressures shall be measured before and after a set of test runs and shall be within ± 5 % of each other. The track width adjustment shall be that which is usual for normal field work with the tractor on which the seat is fitted.

When measurements are made under conditions different from those specified above, all differences shall be reported.

11 Measurement sites and operating conditions

11.1 General

Measurements shall be made on artificial test tracks or on actual work (field) sites (see annex A). The measurement sites and operating conditions shall be appropriate for the machine under test. Where possible, the speed, load and any other relevant operating conditions of the machine shall be kept constant throughout the measurement period and shall be measured to an accuracy of ± 5 %. The measurements shall be made when the ambient temperature is within the range from 5 °C to 30 °C.

11.2 Artificial test track measurements

11.2.1 Track description

Vibration measurements shall be made when the tractor is driven over one or both of the following:

a) a 35 m rougher track;

b) a 100 m smoother track.

Each track shall consist of two parallel strips suitably spaced for the wheel track of the tractor. The surface of each strip shall be either cast in smoothly surfaced concrete or formed of pieces of wood, steel or concrete sited firmly in a base framework. The surface of each track strip shall be defined by the ordinates of elevation, with respect to a level base, listed in Tables 1 and 2. For the rougher track (see Table 1), the elevation shall be defined at intervals of 80 mm along each strip; for the smoother track (see Table 2), the elevation shall be defined at intervals of 160 mm.

The strips shall be firmly sited on level ground and at each point along their length shall have negligible variation across their width, which shall be sufficient for the tractor wheels to be fully supported. Where the strips are constructed of pieces of wood or steel or concrete, these shall be 60 mm to 80 mm thick. They shall be spaced at 160 mm intervals for the smoother track and at 80 mm intervals for the rougher track, but if it is more convenient, 80 mm intervals may be used for the smoother track (with linear interpolation of the data in Table 2 for the heights of the intermediate points).

11.2.2 Operating speeds

For the smoother track, the tractor shall be operated at speeds of 10 km/h, 12 km/h and 14 km/h. For the rougher track, the tractor shall be operated at speeds of 4 km/h, 5 km/h and 7 km/h. The rms values of the weighted vibration along the three axes for each test run shall be determined.

11.2.3 Reported values

Measurements shall be made when the whole of the tractor wheelbase is on or over the track surface.

Five (5) runs shall be made at each speed for each weight of operator. For each run, the values for a_{wx}, a_{wy}, and a_{wz} shall be determined. The reported vibration values shall then be the mean and standard deviation values for a_{wx}, a_{wy}, and a_{wz} for each axis at each of the three operating speeds as determined from the values measured at each of those speeds.

12 Test report

The test report shall contain all the information necessary to understand, interpret and use the results arising from the application of this International Standard.

A specimen report is included in annex B to show the way in which the test results shall be reported. As shown in this annex B, the test report shall contain the following information:

a) name and address of tractor or field machine manufacturer;

b) type and model of tractor/machine;

c) date of test;

d) tractor/machine details:

   1) mass (total, front and rear);

   2) cab or protective frame;

   3) tyres (manufacturer, type and size, pressure for both front and rear);

   4) make and model of seat;

   5) tread width settings, front and rear;

   6) other details;

e) site details;

   1) type of surface;

   2) condition of surface;

   3) details of ground profile or power spectrum (if available);

   4) function of tractor/machine (if working);

   5) ambient temperature;

f) driver details;

   1) mass;

g) vibration measurements;

   1) speeds;

   2) sampling time at each speed;

   3) mean and standard deviation values of the weighted vibration at each speed for each axis;

h) name of the person responsible for the test;

i) identification of test laboratory.

Table 1 — Rougher track — Ordinates of elevation with respect to an arbitrary baseline

D m	*L* mm	*R* m	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
0,00	160	90	4,24	85	90	8,48	125	110	12,72	100	75
0,08	160	115	4,32	85	90	8,56	115	115	12,80	90	95
0,16	165	140	4,40	115	75	8,64	125	110	12,88	85	75
0,24	155	135	4,48	145	55	8,72	140	100	12,96	75	55
0,32	135	135	4,56	150	55	8,80	125	95	13,04	85	65
0,40	135	115	4,64	125	50	8,88	115	90	13,12	90	70
0,48	140	100	4,72	110	55	8,96	110	75	13,20	95	55
0,56	145	95	4,80	90	55	9,04	110	70	13,28	100	50
0,64	150	90	4,88	75	65	9,12	100	45	13,36	115	50
0,72	140	85	4,96	50	50	9,20	100	25	13,44	135	50
0,80	135	75	5,04	50	50	9,28	100	5	13,52	140	65
0,88	135	90	5,12	55	40	9,36	85	40	13,60	145	75
0,96	135	100	5,20	55	20	9,44	65	50	13,68	150	90
1,04	125	95	5,28	55	20	9,52	65	65	13,76	140	85
1,12	120	95	5,36	55	20	9,60	70	75	13,84	115	75
1,20	120	95	5,44	50	25	9,68	70	85	13,92	100	90
1,28	115	95	5,52	45	25	9,76	75	90	14,00	95	100
1,36	120	100	5,60	45	25	9,84	75	75	14,08	90	95
1,44	125	110	5,68	50	30	9,92	85	75	14,16	85	90
1,52	135	100	5,76	45	40	10,00	100	75	14,24	90	70
1,60	115	90	5,84	45	50	10,08	115	75	14,32	95	50
1,68	90	95	5,92	45	45	10,16	115	75	14,40	55	45
1,76	70	95	6,00	40	40	10,24	115	75	14,48	25	40
1,84	50	90	6,08	55	30	10,32	120	90	14,56	40	30
1,92	50	75	6,16	90	25	10,40	125	100	14,64	50	25
2,00	55	65	6,24	100	30	10,48	125	90	14,72	55	45
2,08	70	50	6,32	100	40	10,56	135	75	14,80	55	45
2,16	85	40	6,40	95	50	10,64	90	95	14,88	75	55
2,24	85	45	6,48	85	70	10,72	45	125	14,96	90	70
2,32	85	55	6,56	70	90	10,80	45	135	15,04	110	75
2,40	85	55	6,64	50	110	10,88	45	125	15,12	135	90
2,48	75	55	6,72	40	125	10,96	45	115	15,20	120	95
2,56	75	65	6,80	40	110	11,04	45	85	15,28	100	100
2,64	75	75	6,88	30	90	11,12	50	55	15,36	95	100
2,72	95	85	6,96	30	65	11,20	65	50	15,44	100	85
2,80	115	90	7,04	25	45	11,28	75	40	15,52	115	65
2,88	135	75	7,12	25	40	11,36	95	70	15,60	110	50
2,96	150	65	7,20	30	20	11,44	115	95	15,68	100	40
3,04	165	70	7,28	50	25	11,52	150	120	15,76	100	65
3,12	160	75	7,36	65	30	11,60	190	145	15,84	110	90
3,20	135	75	7,44	75	40	11,68	170	125	15,92	115	85
3,28	125	55	7,52	85	45	11,76	150	115	16,00	120	75
3,36	115	40	7,60	75	65	11,84	125	95	16,08	125	90
3,44	115	45	7,68	75	90	11,92	100	75	16,16	140	100
3,52	120	50	7,76	70	100	12,00	100	70	16,24	125	90
3,60	110	55	7,84	90	95	12,08	100	65	16,32	115	75
3,68	100	70	7,92	100	95	12,16	90	55	16,40	110	90
3,76	110	75	8,00	115	110	12,24	95	55	16,48	100	100
3,84	110	75	8,08	125	115	12,32	115	65	16,56	100	95
3,92	90	65	8,16	135	115	12,40	110	70	16,64	95	95
4,00	75	55	8,24	135	115	12,48	100	70	16,72	115	115
4,08	75	75	8,32	125	110	12,56	110	65	16,80	145	140
4,16	75	90	8,40	125	100	12,64	115	65	16,88	150	150

Table 1 (*continued*)

D m	*L* mm	*R* m	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
16,96	160	145	21,28	135	100	25,60	100	70	29,92	210	235
17,04	160	145	21,36	140	100	25,68	90	70	30,00	200	220
17,12	150	125	21,44	145	110	25,76	75	75	30,08	190	195
17,20	145	100	21,52	160	115	25,84	90	85	30,16	205	215
17,28	150	110	21,60	170	115	25,92	90	65	30,24	175	190
17,36	160	135	21,68	165	120	26,00	70	45	30,32	150	185
17,44	160	140	21,76	165	120	26,08	45	30	30,40	130	175
17,52	165	145	21,84	160	120	26,16	15	15	30,48	130	175
17,60	150	150	21,92	150	115	26,24	15	20	30,56	140	165
17,68	135	165	22,00	150	120	26,32	30	15	30,64	165	160
17,76	135	150	22,08	145	125	26,40	40	40	30,72	155	145
17,84	135	145	22,16	150	125	26,48	50	50	30,80	145	140
17,92	125	145	22,24	150	125	26,56	75	70	30,88	155	140
18,00	115	140	22,32	140	140	26,64	100	90	30,96	145	140
18,08	115	135	22,40	125	160	26,72	135	120	31,04	150	140
18,16	120	135	22,48	135	140	26,80	165	150	31,12	135	135
18,24	125	120	22,56	140	125	26,88	200	160	31,20	130	125
18,32	140	100	22,64	135	125	26,96	240	165	31,28	120	110
18,40	160	100	22,72	125	125	27,04	255	165	31,36	100	110
18,48	145	100	22,80	145	135	27,12	265	160	31,44	85	110
18,56	135	100	22,88	160	150	27,20	245	155	31,52	85	100
18,64	125	95	22,96	160	160	27,28	225	160	31,60	100	100
18,72	125	90	23,04	150	145	27,36	215	165	31,68	100	95
18,80	115	85	23,12	150	135	27,44	220	180	31,76	110	100
18,88	95	85	23,20	160	140	27,52	225	190	31,84	135	100
18,96	100	90	23,28	160	145	27,60	245	190	31,92	155	105
19,04	110	115	23,36	165	135	27,68	255	190	32,00	165	105
19,12	110	100	23,44	170	120	27,76	255	185	32,08	160	105
19,20	115	95	23,52	160	140	27,84	265	185	32,16	160	110
19,28	125	85	23,60	145	150	27,92	265	195	32,24	130	120
19,36	140	75	23,68	165	150	28,00	250	195	32,32	105	125
19,44	150	85	23,76	185	145	28,08	270	210	32,40	90	125
19,52	165	90	23,84	185	145	28,16	280	215	32,48	80	130
19,60	165	90	23,92	180	150	28,24	265	235	32,56	75	125
19,68	165	95	24,00	190	135	28,32	270	250	32,64	75	135
19,76	125	100	24,08	190	115	28,40	260	260	32,72	90	125
19,84	100	110	24,16	160	115	28,48	255	275	32,80	100	115
19,92	110	115	24,24	125	120	28,56	255	275	32,88	105	115
20,00	100	120	24,32	125	125	28,64	265	285	32,96	100	115
20,08	100	120	24,40	115	160	28,72	265	260	33,04	105	110
20,16	110	120	24,48	115	160	28,80	280	240	33,12	110	110
20,24	115	120	24,56	100	140	28,88	285	225	33,20	90	130
20,32	125	115	24,64	85	125	28,96	285	225	33,28	75	160
20,40	135	110	24,72	75	115	29,04	285	235	33,36	90	160
20,48	145	100	24,80	75	110	29,12	270	235	33,44	100	165
20,56	150	95	24,88	95	100	29,20	255	240	33,52	100	150
20,64	165	100	24,96	115	100	29,28	250	235	33,60	85	150
20,72	180	110	25,04	115	75	29,36	245	235	33,68	70	150
20,80	180	110	25,12	115	55	29,44	235	235	33,76	75	135
20,88	170	110	25,20	140	50	29,52	230	230	33,84	80	130
20,96	125	100	25,28	165	45	29,60	230	230	33,92	75	120
21,04	100	95	25,36	150	65	29,68	235	220	34,00	75	110
21,12	120	100	25,44	140	75	29,76	240	215	34,08	70	95
21,20	125	110	25,52	120	75	29,84	225	225	34,16	55	80

Table 1 (*continued*)

D m	*L* mm	*R* m	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
34,24	40	65	34,48	35	65	34,72	40	80	34,96	45	55
34,32	30	70	34,56	45	65	34,80	55	80	35,04	30	40
34,40	30	70	34,64	40	85	34,88	55	65	–	–	–

Table 2 — Smoother track — Ordinates of elevation with respect to an arbitrary baseline

D m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
0,00	115	140	8,48	110	100	16,96	65	85	25,44	110	95
0,16	110	125	8,64	110	95	17,12	65	70	25,60	100	95
0,32	110	140	8,80	110	95	17,28	65	65	25,76	115	100
0,48	115	135	8,96	110	95	17,44	65	75	25,92	115	100
0,64	120	135	9,12	110	100	17,60	55	75	26,08	110	95
0,80	120	125	9,28	125	90	17,76	50	75	26,24	115	95
0,96	125	135	9,44	120	100	17,92	55	85	26,40	110	95
1,12	120	125	9,60	135	95	18,08	55	85	26,56	100	95
1,28	120	115	9,76	120	95	18,24	65	85	26,72	100	95
1,44	115	110	9,92	120	95	18,40	70	75	26,88	100	100
1,60	110	100	10,08	120	95	18,56	75	75	27,04	100	95
1,76	110	110	10,24	115	85	18,72	95	75	27,20	100	95
1,92	110	110	10,40	115	90	18,88	90	75	27,36	110	90
2,08	115	115	10,56	115	85	19,04	90	70	27,52	115	90
2,24	110	110	10,72	115	90	19,20	95	70	27,68	115	85
2,40	100	110	10,88	120	90	19,36	85	70	27,84	110	90
2,56	100	100	11,04	110	75	19,52	85	75	28,00	110	85
2,72	95	110	11,20	110	75	19,68	75	85	28,16	110	85
2,88	95	95	11,36	100	85	19,84	85	85	28,32	100	85
3,04	90	95	11,52	110	85	20,00	75	90	28,48	100	90
3,20	90	100	11,68	95	90	20,16	85	85	28,64	90	85
3,36	85	100	11,84	95	90	20,32	75	70	28,80	90	75
3,52	90	100	12,00	95	85	20,48	70	75	28,96	75	90
3,68	90	115	12,16	100	95	20,64	65	75	29,12	75	75
3,84	95	110	12,32	100	90	20,80	70	75	29,28	75	75
4,00	90	110	12,48	95	85	20,96	65	75	29,44	70	75
4,16	90	95	12,64	95	85	21,12	70	75	29,60	75	75
4,32	95	100	12,80	95	90	21,28	70	85	29,76	75	85
4,48	100	100	12,96	85	90	21,44	70	85	29,92	85	75
4,64	100	90	13,12	85	85	21,60	70	90	30,08	75	75
4,80	90	90	13,28	75	90	21,76	75	95	30,24	85	75
4,96	90	90	13,44	75	95	21,92	75	95	30,40	75	75
5,12	95	90	13,60	75	90	22,08	75	90	30,56	70	75
5,28	95	70	13,76	70	75	22,24	85	90	30,72	75	75
5,44	95	65	13,92	70	90	22,40	85	95	30,88	85	75
5,60	90	50	14,08	70	100	22,56	90	85	31,04	90	75
5,76	95	50	14,24	70	100	22,72	90	85	31,20	90	85
5,92	85	50	14,40	65	95	22,88	95	85	31,36	100	75
6,08	85	55	14,56	65	100	23,04	95	85	31,52	100	75
6,24	75	55	14,72	65	90	23,20	100	85	31,68	120	85
6,40	75	55	14,88	65	90	23,36	100	75	31,84	115	75
6,56	70	65	15,04	65	85	23,52	110	85	32,00	120	85
6,72	75	75	15,20	55	85	23,68	110	85	32,16	120	85
6,88	65	75	15,36	65	85	23,84	110	85	32,32	135	90
7,04	65	85	15,52	65	85	24,00	100	75	32,48	145	95
7,20	65	90	15,68	55	75	24,16	100	75	32,64	160	95
7,36	75	95	15,84	55	85	24,32	95	70	32,80	165	90
7,52	75	100	16,00	65	75	24,48	100	70	32,96	155	90
7,68	95	95	16,16	55	85	24,64	100	70	33,12	145	90
7,84	115	110	16,32	50	75	24,80	115	75	33,28	140	95
8,00	115	100	16,48	55	75	24,96	110	75	33,44	140	85
8,16	125	110	16,64	65	75	25,12	110	85	33,60	140	85
8,32	110	100	16,80	65	75	25,28	100	75	33,76	125	75

Table 2 (*continued*)

D m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
33,92	125	75	42,40	85	110	50,88	95	120	59,36	90	115
34,08	115	85	42,56	95	110	51,04	95	120	59,52	90	115
34,24	120	75	42,72	95	115	51,20	90	135	59,68	85	110
34,40	125	75	42,88	95	115	51,36	95	125	59,84	75	110
34,56	115	85	43,04	100	100	51,52	95	120	60,00	90	115
34,72	115	75	43,20	100	95	51,68	100	120	60,16	90	120
34,88	115	90	43,36	100	95	51,84	100	120	60,32	90	120
35,04	115	100	43,52	100	90	52,00	100	120	60,48	90	120
35,20	120	100	43,68	110	95	52,16	100	125	60,64	95	120
35,36	120	100	43,84	100	100	52,32	110	125	60,80	95	120
35,52	135	95	44,00	110	90	52,48	110	125	60,96	90	120
35,68	135	95	44,16	100	85	52,64	100	125	61,12	90	115
35,84	135	95	44,32	110	90	52,80	100	120	61,28	95	110
36,00	135	90	44,48	110	85	52,96	100	120	61,44	95	110
36,16	120	75	44,64	100	85	53,12	110	115	61,60	100	100
36,32	115	75	44,80	100	90	53,28	100	110	61,76	110	100
36,48	110	70	44,96	95	90	53,44	110	110	61,92	100	100
36,64	100	65	45,12	90	95	53,60	95	110	62,08	100	100
36,80	110	55	45,28	90	100	53,76	95	110	62,24	95	100
36,96	115	55	45,44	95	100	53,92	100	110	62,40	95	100
37,12	100	50	45,60	90	90	54,08	95	100	62,56	95	100
37,28	115	50	45,76	85	90	54,24	100	100	62,72	90	100
37,44	110	50	45,92	75	90	54,40	100	100	62,88	90	100
37,60	100	65	46,08	85	90	54,56	100	100	63,04	90	100
37,76	90	55	46,24	75	90	54,72	95	100	63,20	90	90
37,92	95	55	46,40	75	90	54,88	100	100	63,36	90	90
38,08	90	35	46,56	75	90	55,04	100	115	63,52	85	90
38,24	90	35	46,72	85	90	55,20	110	115	63,68	85	90
38,40	110	35	46,88	85	85	55,36	100	110	63,84	75	85
38,56	100	35	47,04	90	85	55,52	110	100	64,00	75	85
38,72	115	35	47,20	75	85	55,68	100	110	64,16	75	75
38,88	100	35	47,36	65	75	55,84	100	110	64,32	75	75
39,04	100	35	47,52	70	70	56,00	100	110	64,48	70	75
39,20	110	30	47,68	70	75	56,16	95	115	64,64	70	70
39,36	110	45	47,84	70	75	56,32	90	110	64,80	70	55
39,52	110	50	48,00	75	85	56,48	95	110	64,96	70	45
39,68	100	55	48,16	90	95	56,64	95	110	65,12	65	55
39,84	110	50	48,32	95	95	56,80	90	100	65,28	65	55
40,00	90	55	48,48	100	120	56,96	100	100	65,44	65	65
40,16	85	55	48,64	110	100	57,12	100	95	65,60	55	70
40,32	90	65	48,80	115	100	57,28	95	100	65,76	55	75
40,48	90	65	48,96	115	115	57,44	100	100	65,92	55	75
40,64	90	70	49,12	120	115	57,60	95	115	66,08	55	75
40,80	95	75	49,28	120	110	57,76	85	110	66,24	55	85
40,96	95	75	49,44	115	95	57,92	90	115	66,40	55	85
41,12	95	75	49,60	115	90	58,08	90	110	66,56	65	90
41,28	90	90	49,76	115	90	58,24	90	100	66,72	70	90
41,44	90	95	49,92	110	95	58,40	85	95	66,88	70	110
41,60	85	95	50,08	110	100	58,56	90	95	67,04	65	100
41,76	85	100	50,24	100	110	58,72	85	90	67,20	55	100
41,92	90	100	50,40	100	120	58,88	90	90	67,36	65	100
42,08	90	95	50,56	95	120	59,04	90	95	67,52	50	100
42,24	85	100	50,72	95	115	59,20	90	115	67,68	50	85

Table 2 (*continued*)

D m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm	*D* m	*L* mm	*R* mm
67,84	50	90	76,48	100	125	85,12	115	155	93,76	115	140
68,00	50	100	76,64	110	125	85,28	120	160	93,92	115	140
68,16	55	100	76,80	115	125	85,44	120	165	94,08	115	140
68,32	55	95	76,96	120	125	85,60	120	160	94,24	115	140
68,48	65	90	77,12	120	125	85,76	125	165	94,40	115	140
68,64	50	85	77,28	120	135	85,92	135	160	94,56	115	140
68,80	50	70	77,44	110	125	86,08	135	160	94,72	115	135
68,96	50	70	77,60	100	125	86,24	125	155	94,88	115	135
69,12	50	55	77,76	120	135	86,40	125	155	95,04	110	135
69,28	50	55	77,92	120	125	86,56	120	145	95,20	110	135
69,44	45	50	78,08	120	125	86,72	120	145	95,36	110	135
69,60	35	50	78,24	115	125	86,88	110	140	95,52	115	135
69,76	35	55	78,40	115	120	87,04	110	140	95,68	100	140
69,92	35	65	78,56	115	120	87,20	110	140	95,84	95	135
70,08	35	65	78,72	110	120	87,36	110	140	96,00	100	125
70,24	35	65	78,88	100	120	87,52	110	140	96,16	95	125
70,40	35	55	79,04	100	120	87,68	100	135	96,32	95	125
70,56	45	55	79,20	95	120	87,84	100	135	96,48	95	125
70,72	50	55	79,36	95	120	88,00	100	135	96,64	110	125
70,88	50	50	79,52	95	125	88,16	100	125	96,80	95	120
71,04	50	45	79,68	95	125	88,32	110	120	96,96	95	120
71,20	50	45	79,84	100	120	88,48	115	120	97,12	95	120
71,36	50	50	80,00	95	125	88,64	110	120	97,28	95	110
71,52	45	45	80,16	95	125	88,80	110	125	97,44	100	115
71,68	45	55	80,32	95	125	88,96	100	125	97,60	110	120
71,84	55	65	80,48	100	120	89,12	100	125	97,76	110	115
72,00	55	65	80,64	100	125	89,28	95	125	97,92	100	115
72,16	70	65	80,80	100	125	89,44	95	125	98,08	95	115
72,32	70	75	80,96	110	125	89,60	100	120	98,24	100	115
72,48	75	85	81,12	115	135	89,76	100	135	98,40	95	115
72,64	75	85	81,28	110	140	89,92	110	140	98,56	100	115
72,80	75	90	81,44	115	140	90,08	110	135	98,72	100	110
72,96	85	95	81,60	110	140	90,24	110	140	98,88	110	100
73,12	90	100	81,76	115	140	90,40	100	145	99,04	95	95
73,28	90	110	81,92	110	140	90,56	100	155	99,20	90	100
73,44	90	115	82,08	110	140	90,72	110	155	99,36	90	100
73,60	90	120	82,24	110	135	90,88	110	155	99,52	75	110
73,76	90	115	82,40	110	135	91,04	100	155	99,68	75	115
73,92	90	115	82,56	100	125	91,20	110	155	99,84	75	115
74,08	110	115	82,72	110	125	91,36	110	160	100,00	75	110
74,24	100	110	82,88	110	125	91,52	115	160	–	–	–
74,40	100	110	83,04	100	125	91,68	110	155	–	–	–
74,56	100	110	83,20	100	120	91,84	115	155	–	–	–
74,72	95	115	83,36	100	125	92,00	115	140	–	–	–
74,88	95	120	83,52	100	120	92,16	115	155	–	–	–
75,04	95	125	83,68	100	135	92,32	120	155	–	–	–
75,20	95	135	83,84	95	140	92,48	125	145	–	–	–
75,36	100	135	84,00	100	135	92,64	125	155	–	–	–
75,52	100	140	84,16	110	140	92,80	125	155	–	–	–
75,68	100	140	84,32	110	140	92,96	120	155	–	–	–
75,84	100	140	84,48	110	140	93,12	120	145	–	–	–
76,00	110	135	84,64	110	140	93,28	120	145	–	–	–
76,16	100	125	84,80	120	155	93,44	115	145	–	–	–
76,32	100	125	84,96	115	145	93,60	120	145	–	–	–

Annex A
(informative)

Field measurements

A.1 Application

This annex provides a method for measuring the vibration exposure of the operator of an agricultural tractor or field machine under non-standard test conditions.

A.2 Variability

Field measurements of operator vibration tend to be quite variable due to differences in the exact path followed, speed fluctuations, weather, temperature and the operator's driving habits. When attempting to obtain data for comparative purposes, the best results are obtained if all of the data is acquired while attempting to hold these variables as nearly constant as possible. That generally means that the data should be acquired on the same day under the same weather conditions with the same operator.

Also, more stable results are obtained if the data are acquired over relatively long time periods (typically, 3 min or more).

A.3 Field description

The field conditions should be recorded in detail, including general condition of the site, soil characteristics, surface cover, surface ridges due to previous tillage operations and direction of operation with respect to those ridges, grades, etc. Where possible, the ground profile and/or its power spectrum should also be recorded.

A.4 Operating speeds

Where appropriate for agricultural equipment, ground speed should be kept relatively constant throughout each measuring period and the average ground speed during the period reported. If the vibration test is being conducted during a work cycle that involves several operating speeds and/or operating conditions, then a separate measuring period should be devoted to each such segment of the work cycle and the corresponding results so reported along with a description of the work cycle involved. Where the speeds and/or operating conditions are constantly varying during the work cycle, such that discrete separate cycle segments are extremely short in duration or non-existent, the work cycle can be measured on a continuous basis.

A.5 Integration time

In all cases, the sampling time should be as long as is required to obtain vibration measurements representative of the machine and operating conditions. The minimum sampling time is defined by:

$$2 \times B_{\mathrm{e}} \times T_{\mathrm{s}} > 140$$

$$B_{\mathrm{e}} < 0{,}5 \text{ Hz}$$

If the vibration test is conducted during a work cycle that involves several discrete separate segments, the minimum sampling time requirement should be applied to each such segment. The minimum sampling time may be obtained by combining like segments during either the actual test or the data analysis.

A.6 Reported values

Eight to ten (8 to 10) runs should be made at each speed of interest. For each run, the rms values of the weighted vibration along the three axes (a_{wx}, a_{wy}, and a_{wz}) should be determined. The reported vibration values should then be the mean and standard deviation values for a_{wx}, a_{wy}, and a_{wz} at each of the three operating speeds as determined from the values measured at each of those speeds.

Annex B
(informative)

Specimen report of measurement of whole body vibration of the operator of an agricultural tractor or field machine

1. Name and address of manufacturer _____

2. Type and model of vehicle _____

3. Date of tests _____

4. Tractor or machine details

   a) Mass (total)_____kg,(front)_____ kg,(rear) _____kg

   b) Whether cab or protective frame fitted_____

   c) Front tyres: manufacturer_____

      type and size _____pressure _____kpa

   d) Rear tyres: manufacturer_____

      type and size _____pressure _____kpa

   e) Make and model of seat_____

      SEAT values for light operator (If applicable) Tractor class AG1_____ class AG2 ____ class AG3 ____

      SEAT values for heavy operator (If applicable) Tractor class AG1 _____ class AG2 ____ class AG3 ____

   f) Tread width setting(s) (front) _____mm,(rear)_____mm

   g) Other details (including attached equipment)_____

5. Site details

   a) type of surface_____

   b) condition of surface_____

   c) details of ground profile or power spectrum (if available)_____

   d) functioning of tractor/machine (if working)_____

   e) ambient temperature_____°C

6. Driver mass (one or more) _____kg

7. Vibration measurements

Measured values (light operator):

Average speed (km/h)	Average sample time for a run T_s (s)	Wtd longitudinal (a_{wx}) acceleration (m/s^2)		Wtd lateral (a_{wy}) acceleration (m/s^2)		Wtd vertical (a_{wz}) acceleration (m/s^2)	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.

Measured values (heavy operator):

Average speed (km/h)	Average sample time for a run T_s (s)	Wtd longitudinal (a_{wx}) acceleration (m/s^2)		Wtd lateral (a_{wy}) acceleration (m/s^2)		Wtd vertical (a_{wz}) acceleration (m/s^2)	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.

8. Test conducted by _____ Date _____

Test lab. _____

ICS 13.160; 65.060.01

Price based on 17 pages