International Standard 5008

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

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

Tracteurs et matériels agricoles à roues — Mesurage des vibrations transmises globalement au conducteur

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FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

International Standard ISO 5008 was developed by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, and was circulated to the member bodies in November 1976.

It has been approved by the member bodies of the following countries :

Australia	Hungary	Romania
Austria	India	South Africa, Rep. of
Brazil	Iran	Spain
Bulgaria	Italy	Sweden
Canada	Korea, Dem. P. Rep. of	Switzerland
Chile	Korea, Rep. of	Turkey
Czechoslovakia	Mexico	United Kingdom
Denmark	New Zealand	Yugoslavia
Finland	Poland	
Germany, F. R.	Portugal	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Belgium
France
USSR

Printed in Switzerland

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

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.*

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 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 ± 0,05 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.

The recording equipment shall have a replay accuracy of better than ± 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 values :

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

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)	Weighting factor for 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	0,031 5 = − 30 dB
80,0	0,10 = − 20 dB	0,025 = − 32 dB

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.

$$I = \int_{t=0}^{T} b_w^2 \, dT$$

$$\text{or } I' = \sqrt{\int_{t=0}^{T} b_w^2 \, dT}$$

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

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

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

5.4 Calibration

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

6 MEASUREMENT SITE AND OPERATING CONDITIONS

The measurement site and operating conditions shall be those appropriate for the machine under test. The type of soil and condition of surface shall be recorded, and, where possible, the ground profile or its power spectrum shall also be recorded. The speed, load and any other relevant operating condition of the machine shall be kept constant throughout the measurement period and shall be measured to an accuracy of ± 5 %. The measuring period shall be as long as is required to obtain vibration measurements representative of the machine and operating conditions and shall be specified for each machine.

NOTE — It is recommended that the mass of the operator should also be reported where this is likely to affect the vibration levels. To facilitate comparison of test results, the mass of the operator should, preferably, be 55 kg or 98 kg.

7 REPORTED VIBRATION LEVELS

The weighted vibration level in each of the three directions shall be reported separately, to the nearest 0,1 m/s^2. If the 1/3 octave analysis method has been employed, the weighted accelerations in each 1/3 octave band may be presented graphically.

8 AGRICULTURAL WHEELED TRACTORS : TEST TRACK METHOD

8.1 Condition of tractor

The tractor may be with or without a safety frame or cab. For normal measurements the tractor shall be in working order with full 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 means of the ranges recommended by the manufacturer. The track wheel setting shall be that which is usual for normal field work.

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

8.2 Artificial test tracks

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

a) a 100 m smoother track;

b) a 35 m rougher 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 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 2 and 3. For the smoother track (see table 3), the elevation shall be defined at intervals of 160 mm along each strip; for the rougher track (see table 2), the elevation shall be defined at intervals of 80 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 concrete, these shall be 60 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.

Recommended driving speeds for these tracks are :

a) for the smoother track, 12 km/h;

b) for the rougher track, 5 km/h.

The speeds used shall be reported with an accuracy of ± 5 % of the measured value.

8.3 Tractor vibration

The r.m.s. values of weighted vibration along the three axes throughout the test runs shall be determined and reported together with details of the tractor design, its operating speed, the masses of the operators and the instrumentation employed.

Each measurement shall be carried out at least twice. The results will normally be expected to differ by not more than ± 5 % from the arithmetic mean. Larger discrepancies shall be resolved by further repeat measurements.

9 SPECIMEN REPORT FORM

A specimen report is included in the annex to show the way in which the result should be reported.

Dimensions in millimetres

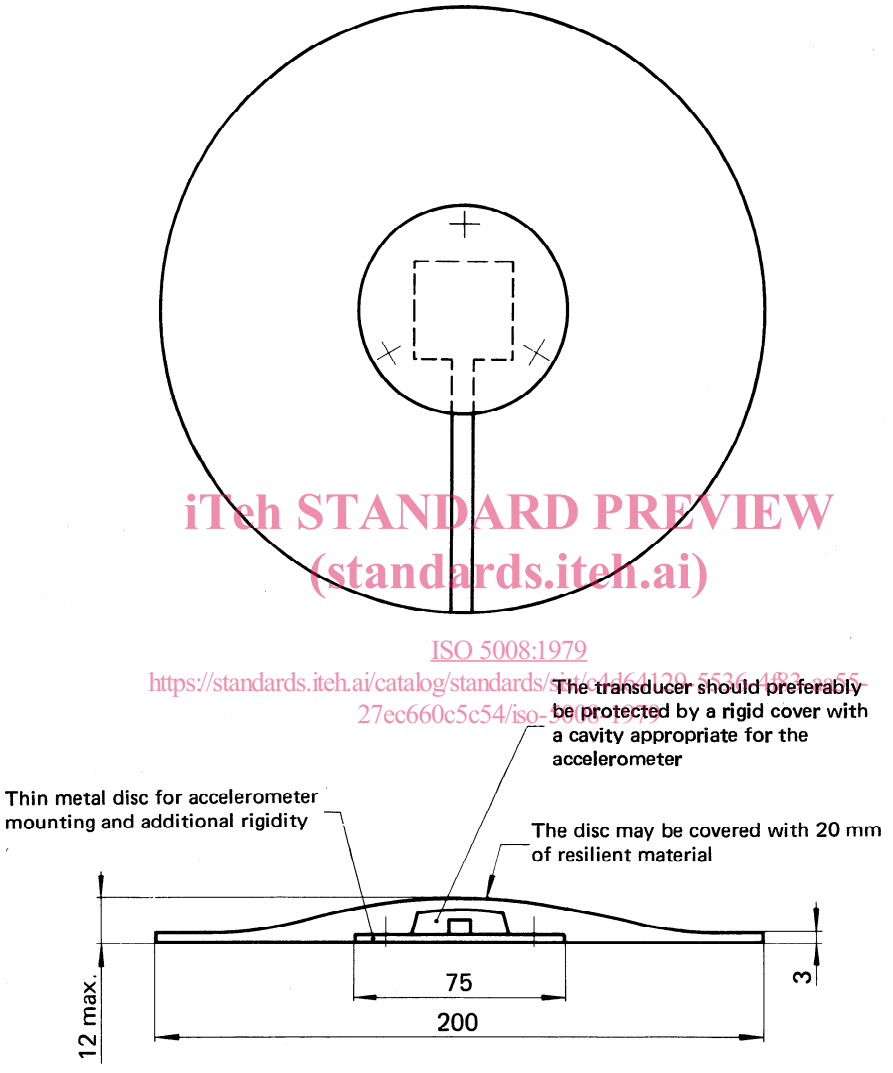

FIGURE 1 — **Suggested design for a semi-rigid disc for accelerometer mounting**

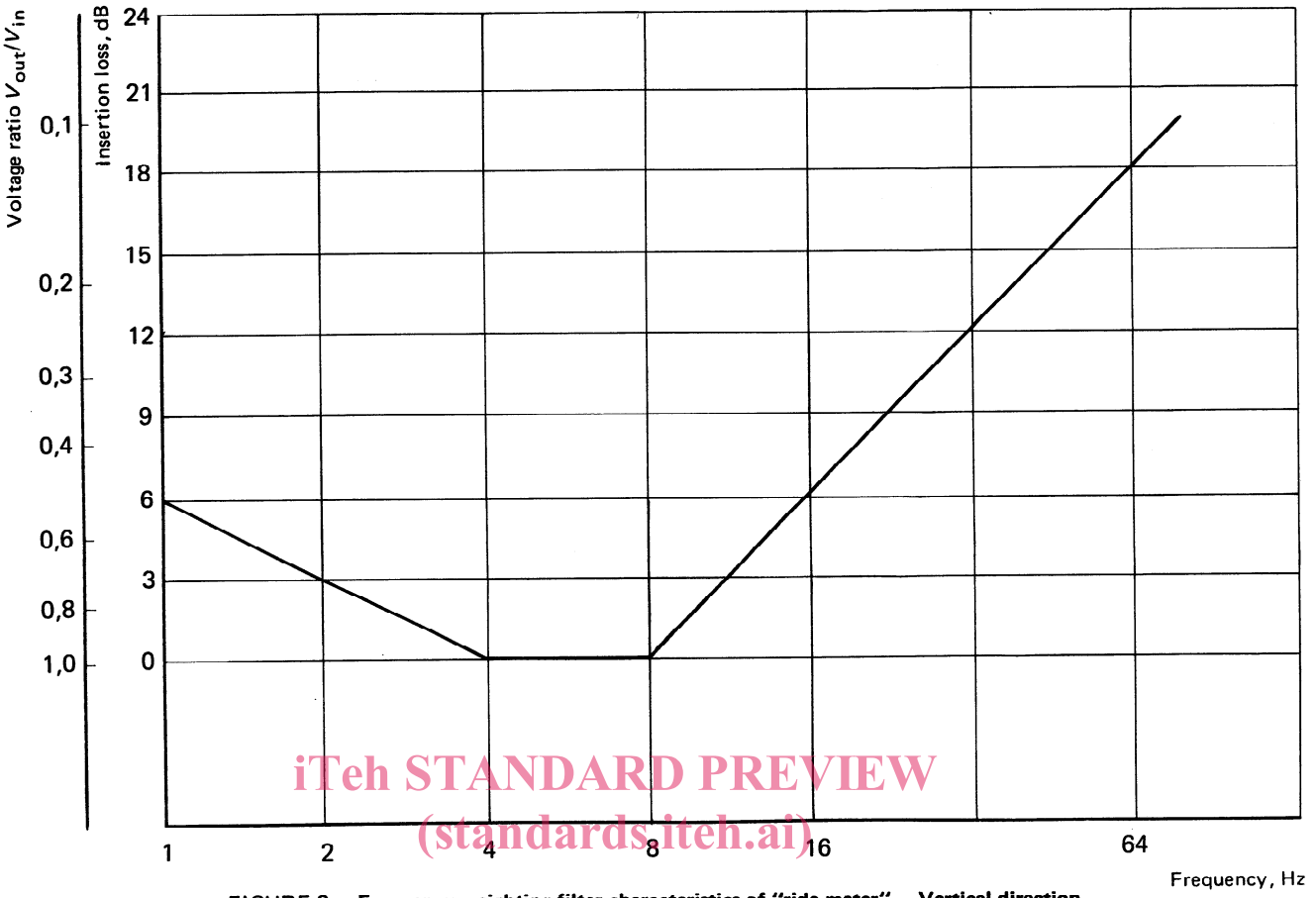

FIGURE 2 – **Frequency-weighting filter characteristics of "ride meter" – Vertical direction**

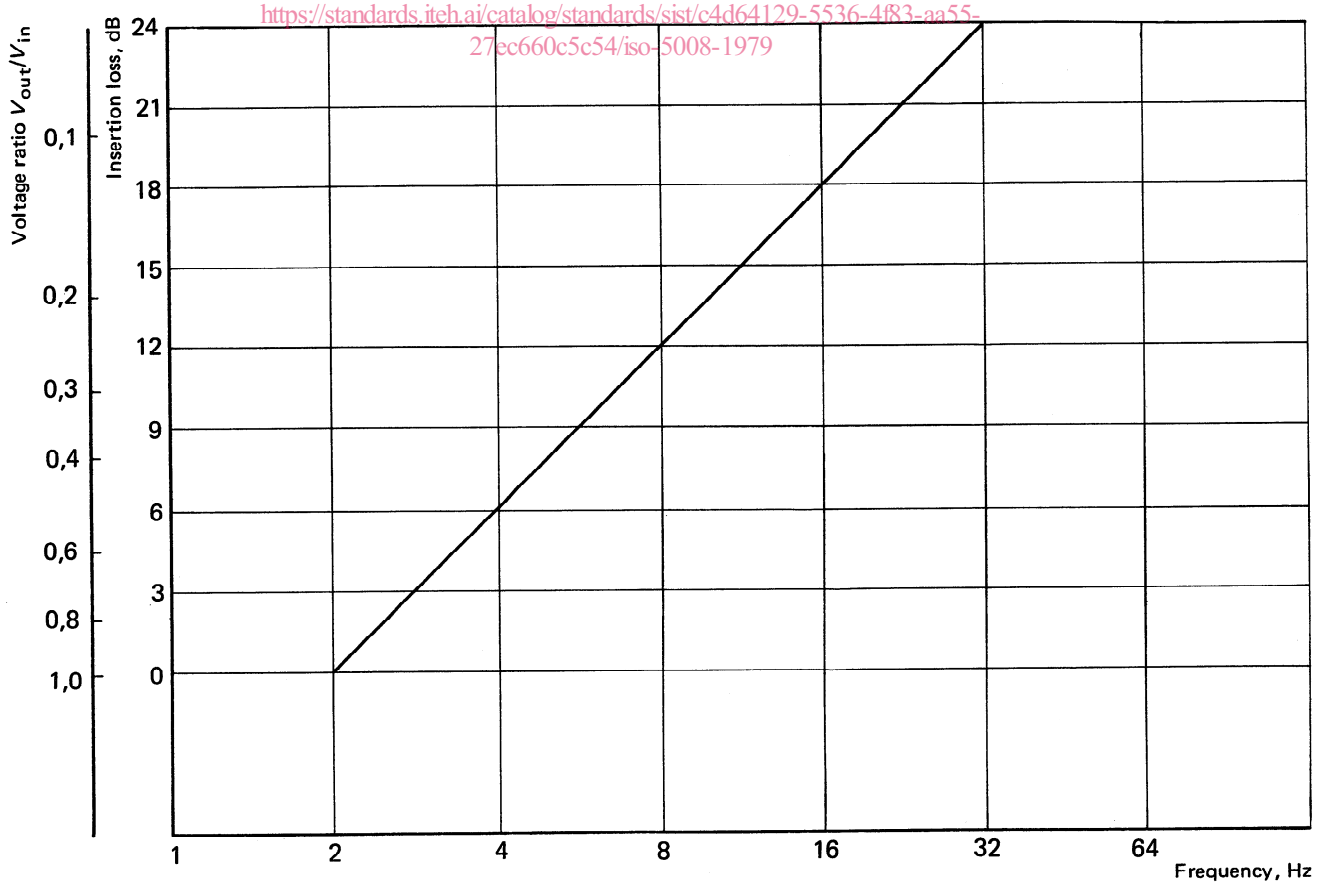

FIGURE 3 – **Frequency-weighting filter characteristics of "ride meter" – Horizontal direction**

TABLE 2 — **Rougher track — Ordinates of elevation with respect to an arbitrary baseline**

D = distance from start (m); L = ordinate of left-hand strip (mm); R = ordinate of right-hand strip (mm)

D	L	R	D	L	R	D	L	R	D	L	R
0	160	90	4,80	90	55	9,60	70	75	14,40	55	45
0,08	160	115	4,88	75	65	9,68	70	85	14,48	25	40
0,16	165	140	4,96	50	50	9,76	75	90	14,56	40	30
0,24	155	135	5,04	50	50	9,84	75	75	14,64	50	25
0,32	135	135	5,12	55	40	9,92	85	75	14,72	55	45
0,40	135	115	5,20	55	20	10,00	100	75	14,80	55	45
0,48	140	100	5,28	55	20	10,08	115	75	14,88	75	55
0,56	145	95	5,36	55	20	10,16	115	75	14,96	90	70
0,64	150	90	5,44	50	25	10,24	115	75	15,04	110	75
0,72	140	85	5,52	45	25	10,32	120	90	15,12	135	90
0,80	135	75	5,60	45	25	10,40	125	100	15,20	120	95
0,88	135	90	5,68	50	30	10,48	125	90	15,28	100	100
0,96	135	100	5,76	45	40	10,56	135	75	15,36	95	100
1,04	125	95	5,84	45	50	10,64	90	95	15,44	100	85
1,12	120	95	5,92	45	45	10,72	45	125	15,52	115	65
1,20	120	95	6,00	40	40	10,80	45	135	15,60	110	50
1,28	115	95	6,08	55	30	10,88	45	125	15,68	100	40
1,36	120	100	6,16	90	25	10,96	45	115	15,76	100	65
1,44	125	110	6,24	100	30	11,04	45	85	15,84	110	90
1,52	135	100	6,32	100	40	11,12	50	55	15,92	115	85
1,60	115	90	6,40	95	50	11,20	65	50	16,00	120	75
1,68	90	95	6,48	85	70	11,28	75	40	16,08	125	90
1,76	70	95	6,56	70	90	11,36	95	70	16,16	140	100
1,84	50	90	6,64	50	110	11,44	115	95	16,24	125	90
1,92	50	75	6,72	40	125	11,52	150	120	16,32	115	75
2,00	55	65	6,80	40	110	11,60	190	145	16,40	110	90
2,08	70	50	6,88	30	90	11,68	170	125	16,48	100	100
2,16	85	40	6,96	30	65	11,76	150	115	16,56	100	95
2,24	85	45	7,04	25	45	11,84	125	95	16,64	95	95
2,32	85	55	7,12	25	40	11,92	100	75	16,72	115	115
2,40	85	55	7,20	30	20	12,00	100	70	16,80	145	140
2,48	75	55	7,28	50	25	12,08	100	65	16,88	150	150
2,56	75	65	7,36	65	30	12,16	90	55	16,96	160	145
2,64	75	75	7,44	75	40	12,24	95	55	17,04	160	145
2,72	95	85	7,52	85	45	12,32	115	65	17,12	150	125
2,80	115	90	7,60	75	65	12,40	110	70	17,20	145	100
2,88	135	75	7,68	75	90	12,48	100	70	17,28	150	110
2,96	150	65	7,76	70	100	12,56	110	65	17,36	160	135
3,04	165	70	7,84	90	95	12,64	115	65	17,44	160	140
3,12	160	75	7,92	100	95	12,72	100	75	17,52	165	145
3,20	135	75	8,00	115	110	12,80	90	95	17,60	150	150
3,28	125	55	8,08	125	115	12,88	85	75	17,68	135	165
3,36	115	40	8,16	135	115	12,96	75	55	17,76	135	150
3,44	115	45	8,24	135	115	13,04	85	65	17,84	135	145
3,52	120	50	8,32	125	110	13,12	90	70	17,92	125	145
3,60	110	55	8,40	125	100	13,20	95	55	18,00	115	140
3,68	100	70	8,48	125	110	13,28	100	50	18,08	115	135
3,76	110	75	8,56	115	115	13,36	115	50	18,16	120	135
3,84	110	75	8,64	125	110	13,44	135	50	18,24	125	120
3,92	90	65	8,72	140	100	13,52	140	65	18,32	140	100
4,00	75	55	8,80	125	95	13,60	145	75	18,40	160	100
4,08	75	75	8,88	115	90	13,68	150	90	18,48	145	100
4,16	75	90	8,96	110	75	13,76	140	85	18,56	135	100
4,24	85	90	9,04	110	70	13,84	115	75	18,64	125	95
4,32	85	90	9,12	100	45	13,92	100	90	18,72	125	90
4,40	115	75	9,20	100	25	14,00	95	100	18,80	115	85
4,48	145	55	9,28	100	05	14,08	90	95	18,88	95	85
4,56	150	55	9,36	85	40	14,16	85	90	18,96	100	90
4,64	125	50	9,44	65	50	14,24	90	70	19,04	110	115
4,72	110	55	9,52	65	65	14,32	95	50	19,12	110	100

TABLE 2 (*concluded*)

D	*L*	*R*	*D*	*L*	*R*	*D*	*L*	*R*	*D*	*L*	*R*
19,20	115	95	23,20	160	140	27,20	245	155	31,20	130	125
19,28	125	85	23,28	160	145	27,28	225	160	31,28	120	110
19,36	140	75	23,36	165	135	27,36	215	165	31,36	100	110
19,44	150	85	23,44	170	120	27,44	220	180	31,44	85	110
19,52	165	90	23,52	160	140	27,52	225	190	31,52	85	100
19,60	165	90	23,60	145	150	27,60	245	190	31,60	100	100
19,68	165	95	23,68	165	150	27,68	255	190	31,68	100	95
19,76	125	100	23,76	185	145	27,76	255	185	31,76	110	100
19,84	100	110	23,84	185	145	27,84	265	185	31,84	135	100
19,92	110	115	23,92	180	150	27,92	265	195	31,92	155	105
20,00	100	120	24,00	190	135	28,00	250	195	32,00	165	105
20,08	100	120	24,08	190	115	28,08	270	210	32,08	160	105
20,16	110	120	24,16	160	115	28,16	280	215	32,16	160	110
20,24	115	120	24,24	125	120	28,24	265	235	32,24	130	120
20,32	125	115	24,32	125	125	28,32	270	250	32,32	105	125
20,40	135	110	24,40	115	160	28,40	260	260	32,40	90	125
20,48	145	100	24,48	115	160	28,48	255	275	32,48	80	130
20,56	150	95	24,56	100	140	28,56	255	275	32,56	75	125
20,64	165	100	24,64	85	125	28,64	265	285	32,64	75	135
20,72	180	110	24,72	75	115	28,72	265	260	32,72	90	125
20,80	180	110	24,80	75	110	28,80	280	240	32,80	100	115
20,88	170	110	24,88	95	100	28,88	285	225	32,88	105	115
20,96	125	100	24,96	115	100	28,96	285	225	32,96	100	115
21,04	100	95	25,04	115	75	29,04	285	235	33,04	105	110
21,12	120	100	25,12	115	55	29,12	270	235	33,12	110	110
21,20	125	110	25,20	140	50	29,20	255	240	33,20	90	130
21,23	135	100	25,28	165	45	29,28	250	235	33,28	75	160
21,36	140	100	25,36	150	65	29,36	245	235	33,36	90	160
21,44	145	110	25,44	140	75	29,44	235	235	33,44	100	165
21,52	160	115	25,52	120	75	29,52	230	230	33,52	100	150
21,60	170	115	25,60	100	70	29,60	230	230	33,60	85	150
21,68	165	120	25,68	90	70	29,68	235	220	33,68	70	150
21,76	165	120	25,76	75	75	29,76	240	215	33,76	75	135
21,84	160	120	25,84	90	85	29,84	225	225	33,84	80	130
21,92	150	115	25,92	90	65	29,92	210	235	33,92	75	120
22,00	150	120	26,00	70	45	30,00	200	220	34,00	75	110
22,08	145	125	26,08	45	30	30,08	190	195	34,08	70	95
22,16	150	125	26,16	15	15	30,16	205	215	34,16	55	80
22,24	150	125	26,24	15	20	30,24	175	190	34,24	40	65
22,32	140	140	26,32	30	15	30,32	150	185	34,32	30	70
22,40	125	160	26,40	40	40	30,40	130	175	34,40	30	70
22,48	135	140	26,48	50	50	30,48	130	175	34,48	35	65
22,56	140	125	26,56	75	70	30,56	140	165	34,56	45	65
22,64	135	125	26,64	100	90	30,64	165	160	34,64	40	85
22,72	125	125	26,72	135	120	30,72	155	145	34,72	40	80
22,80	145	135	26,80	165	150	30,80	145	140	34,80	55	80
22,88	160	150	26,88	200	160	30,88	155	140	34,88	55	65
22,96	160	160	26,96	240	165	30,96	145	140	34,96	45	55
23,04	150	145	27,04	255	165	31,04	150	140	35,04	30	40
23,12	150	135	27,12	265	160	31,12	135	135			