TC 108

International Standard ISO 2631/3

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Evaluation of human exposure to whole-body vibration — Part 3 : Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0,1 to 0,63 Hz

Estimation de l'exposition des individus à des vibrations globales du corps — Partie 3 : Estimation de l'exposition des individus à des vibrations globales verticales du corps dans la gamme de fréquences de 0,1 à 0,63 Hz suivant l'axe des z

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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.

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.

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Evaluation of human exposure to whole-body vibration — Part 3 : Evaluation of exposure to whole-body z-axis vertical vibration in the frequency range 0,1 to 0,63 Hz

0 Introduction

ISO 2631/1 covers vibration in the frequency range 1 to 80 Hz only, although referring to the "special problem in the frequency range below 1 Hz associated with symptoms such as motion sickness". Appreciable vibration in this frequency range occurs in many forms of transport. It causes undesirable effects ranging from discomfort to acute distress due to motion sickness and allied symptoms and interference with activity due to sickness and/or the fluctuating inertial forces it produces in the body.

In some forms of transport at least, it is possible to minimize these unwanted motions by passive or active suspension and control systems, pitch and roll stabilizers, etc., but until recently little or no well-founded guidance existed to help designers optimize such systems. This is probably due firstly to the complexity of the problem, human reaction in this frequency region being extremely variable and depending on factors other than the motion itself, such as vision, odours, age, sex, etc. Secondly there is a surprising lack of worthwhile data from laboratory and field studies which clearly link human reaction with motion input.

The following suggestions for desirable boundaries of vibration below 1 Hz are based on critical surveys and analyses of laboratory and field studies.

The object of these recommendations is firstly to give some design guidance and secondly to stimulate research in this important, neglected area of human response to vibration. Some of the gaps in knowledge have been referred to in this part of ISO 2631, particularly in 3.1.2.

For brevity and clarity of presentation, many of the clauses in ISO 2631/1 which are relevant in principle to vibration below 1 Hz have not been repeated.

1 Scope and field of application

This part of ISO 2631 covers vibration transmitted to the body in the frequency range 0,1 to 0,63 Hz. This part of ISO 2631 applies especially to discrete-frequency and narrow-band vibration and provisionally to random or non-periodic vibrations within the specified frequency range.

The boundaries defined in detail in 3.1 are intended to minimize the severe discomfort associated with motion sickness and allied symptoms. The "severe discomfort" boundary has some similarity to, but is not an extension of, the "exposure limit" (see 4.1.2 in ISO 2631/1) which is intended to protect against pain and permanent injury rather than temporary incapacity.

Because of lack of data, it is not possible to recommend an extension of the fatigue-decreased proficiency boundary below 1 Hz, but suggestions are made on the unwanted effects on activity due to inertial loading. Reference is also made by a "reduced comfort" boundary in 3.3.

Lack of data also confines the recommendations specifically to z-axis vibration only, applied to unadapted sitting or standing fit young men. Tentative factors are suggested for some of the important variables outside these constraints (see 3.1.2).

The existence of measured level exceeding the boundaries contained in this part of ISO 2631 should not be construed as implying that undesirable effects occur or will occur in random vibration environments where experience shows otherwise.

2 Reference

ISO 2631/1, *Evaluation of human exposure to whole-body vibration — Part 1 : General requirements.*

3 Vibration evaluation

3.1 Severe discomfort boundary

3.1.1 The severe discomfort boundary as a function of frequency and exposure time is shown in the table and the figure for exposure times of 30 min, 2 h and, tentatively, 8 h. With some support from the data used, the acceleration a of the boundary as a function of the exposure time t, follows the relationship a^2t = constant. This relationship should be used if interpolation or summation of a varying acceleration time history is required.

NOTE — The term "severe discomfort" (or "malaise") is used in this part of ISO 2631 to characterize the broad spectrum of motion sickness symptoms occurring successively in order of increasing severity or progressing from pallor and dizziness through nausea to vomiting and complete disability. These symptoms vary from subject to subject in severity and duration and change for the same subject depending on circumstances and habitation.

If accelerations or durations beyond those shown in the figure are exceeded, a significant proportion of inexperienced, that is unadapted, seated or standing men in normal health, will experience severe discomfort and temporary disability. (About

10 % incidence at levels at the boundary, increasing as acceleration levels increase beyond this. The boundaries therefore give 90 % cover.)

There is some evidence that motion sickness rarely occurs in the frequency range 0,63 to 1 Hz.

Although the actual levels given are open to many variables (see 3.1.2), the shape is consistent and the message to designers wishing to minimize motion sickness is, if possible, to avoid or at least reduce vibration in the 0,1 to 0,315 Hz region in particular.

3.1.2 Qualifications and extensions

The boundaries apply to z-axis and vertical vibration only. The critical survey and analyses on which this part of ISO 2631 is based, particularly recent studies, suggest that this is normally the dominant direction in which severe reactions are caused in this frequency range. In most transport, other translational and rotational modes occur and may reduce tolerance if superimposed on the z-axis motion. The analyses suggest that where other modes exist, particularly pitch and roll, it may be advisable to reduce the boundary accelerations by about 25 % to maintain the same degree of protection.

The boundaries apply to infrequent (inexperienced) travellers amongst the general public. Many adapt with frequent exposure and for 90 % cover of such populations the boundary could be raised. Alternatively the same boundary would give a greater cover of probably around 95 %. For the normal travelling public, however, it appears that a small percentage of probably about 5 % never adapt to motion below 0,63 Hz. Civil and military vehicle operators will generally have much higher tolerance than the normal travelling public, due to adaptation and selection. Concerning the tentative 8 h boundary, many travellers may acclimatize in the first hour or so of exposure, but such acclimatization will probably include undesirable sickness.

Severall additional influences, particularly vision, fear, head movement, odours and activity and the ingestion of certain foods and drink affect motion sickness sensitivity. It is not possible to quantify their effects at present. The boundaries in the figure exclude the effects of anti-motion sickness drugs, or the use of head restraints.

There is limited evidence that tolerance improves slightly below about 0,2 Hz and the horizontal lines in the figure should certainly not be extrapolated below 0,1 Hz.

Women are apparently more prone to motion sickness than men and for them the boundaries will probably only give about 85 % cover, that is some 15 % will be sick at, or immediately above, the recommended levels. To maintain 90 % cover for women it is likely that accelerations would need to be reduced by about 20 %.

Tolerance also varies considerably with age, and young children for example are known to be particularly sensitive whereas elderly people are probably less sensitive (infants under the age of 18 months, however, have been found to be largely immune to motion sickness). No realistic adjustments can be offered at present to cover this age effect.

Most of the evidence analysed covered discrete or narrow-band frequency only and the recommendations apply particularly to such motion. There has been very limited research into the effects of vibration below 1 Hz, but if more than one frequency or narrow band exist together, a lower limit may apply. The summed weighted method in note 2 of 4.2 of ISO 2631/1 should be used.

NOTES

1 In transport vehicles, the motion should be measured at what are likely to be the most severe positions; that is the areas occupied by passengers or crew most remote from the pitch and roll centre of the vehicles.

2 Activities requiring head movement may well increase the tendency of an individual to motion sickness.

3.2 Decreased proficiency

Because of lack of data, it is not possible to postulate "fatigue-decreased proficiency" boundaries below 1 Hz. The severe discomfort boundaries cover disability due to motion sickness. Below 1 Hz, inertial reaction of the whole body and body members is most noticeable and at certain vibration levels is likely to impair manual dexterity. The acceptable degree of impairment and corresponding acceleration levels will vary greatly with the nature of the task. In the almost complete lack of data on this topic, a r.m.s. value of 1,75 m/s^2, that is a peak value of 0,25 g, largely independent of frequency, is suggested as the approximate level at which disturbance may occur to such tasks as writing and fine manual control.

3.3 Reduced comfort boundary

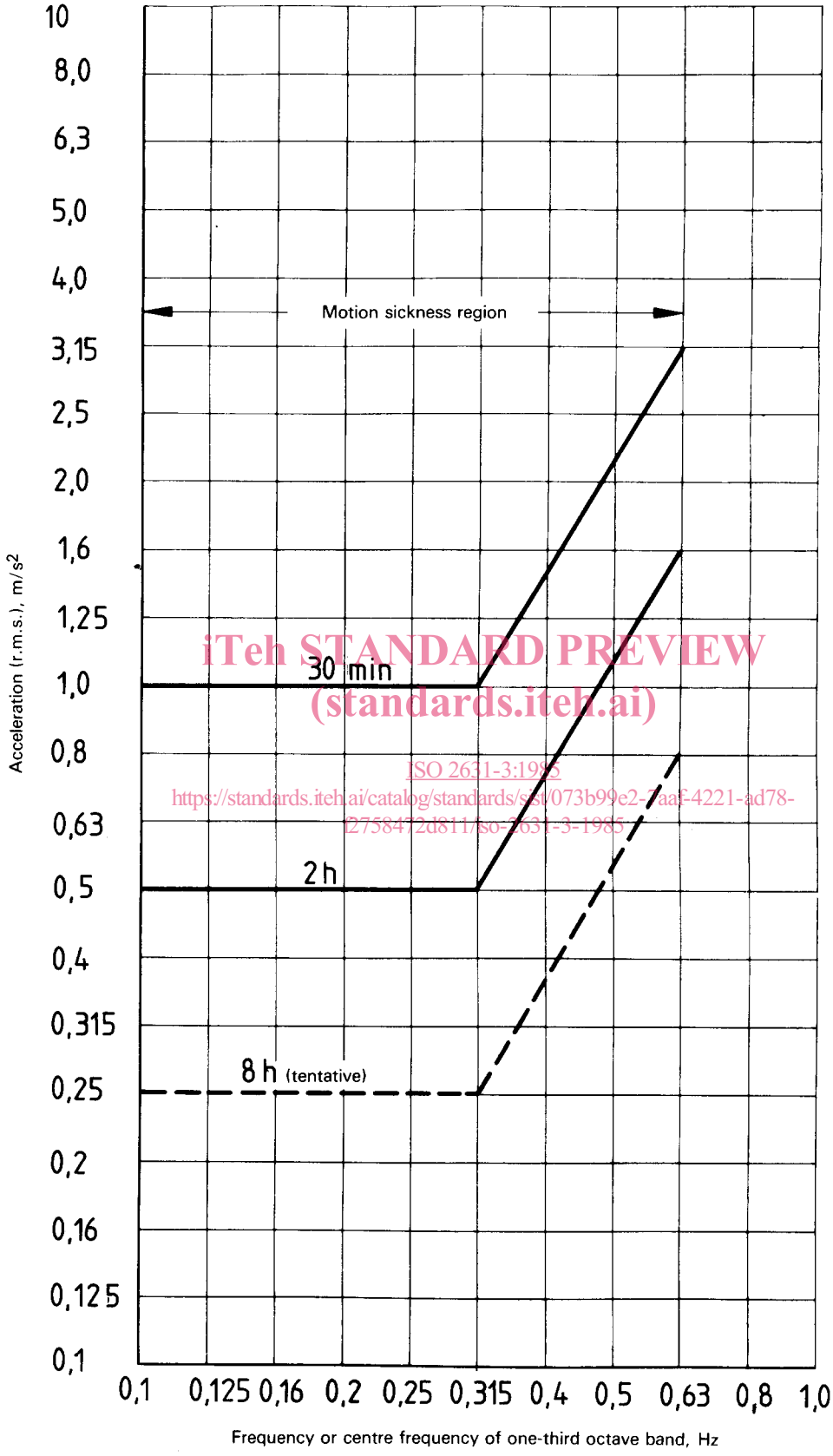
Because of lack of data and the variability of onset of various reduced comfort symptoms, it is not possible to specify a reduced comfort boundary for the 0,1 to 1 Hz frequency range consistent and/or continuous with that for the 1 to 80 Hz range.

NOTE — A constant acceleration sensitivity for the 0,63 Hz to 1 Hz range has been assumed in several applications in accordance with the frequency response for decreased proficiency mentioned in 3.2, but the relationship should not be extrapolated below 0,63 Hz.

Table — Numerical values of "severe discomfort boundaries" for vibration acceleration in the z-axis, a_z (vertical only)

Frequency, Hz (centre frequency of one-third octave band)	Acceleration, m/s^2		
	Exposure times		
	30 min	2 h	8 h
0,10	1,0	0,5	0,25*
0,125	1,0	0,5	0,25*
0,16	1,0	0,5	0,25*
0,20	1,0	0,5	0,25*
0,25	1,0	0,5	0,25*
0,315	1,0	0,5	0,25*
0,40	1,5	0,75	0,375*
0,50	2,15	1,08	0,54*
0,63	3,15	1,60	0,80*

* Tentative values.



NOTE — These boundaries are subject to the qualifications in 3.1.

Figure — "Severe discomfort boundaries", 0,1 to 0,63 Hz for z-axis (a_z) vibration

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