

Guide to

Evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the General Mechanical Engineering Standards Policy Committee (GME/-) to Technical Committee GME/21, upon which the following bodies were represented:

- Department of Trade and Industry (National Engineering Laboratory)
- Electricity Supply Industry in England and Wales
- Engineering Equipment and Materials Users' Association
- Institute of Sound and Vibration Research
- Institution of Mechanical Engineers
- Lloyds Register of Shipping
- Ministry of Defence
- Power Generation Contractors' Association (BEAMA Ltd.)
- Society of British Aerospace Companies Ltd.
- Society of Environmental Engineers
- Society of Motor Manufacturers and Traders Ltd.

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Aggregate Construction Materials Industries
- British Agricultural & Garden Machinery Association Ltd.
- British Coal Corporation
- British Railways Board
- Department of the Environment (Building Research Establishment)
- Forestry Commission
- Health and Safety Executive
- Institute of Naval Medicine
- Institute of Explosives Engineers
- Institution of Civil Engineers
- Medical Research Council
- Silsoe Research Institute
- University College of Swansea
- University of Salford

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Publication(s) referred to	Inside back cover

Foreword

This British Standard has been prepared under the direction of the Mechanical Engineering Standards Policy Committee. It is a revision of BS 6472:1984 which is withdrawn.

International Standard ISO 2631-2 on this subject contains insufficient information to allow proper evaluation of human response to vibration in buildings and, therefore, this British Standard, which conforms in substantial measure with the international agreement and which contains significant additional guidance, has been updated to take account of recent developments on the subject.

A bibliography of supporting data published elsewhere is included in Appendix D of this standard.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, 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

Structural vibration in buildings can be detected by the occupants and can affect them in many ways: their quality of life can be reduced as also can their working efficiency. This standard provides guidance on human response to building vibration. Weighting curves related to human response to vibration of buildings are provided.

Complaint levels from occupants of buildings subject to vibration and the acceptable magnitudes, or limits, for building vibration depend upon specific circumstances. Appendix A provides best available information on the application of the weighting curves to different situations. Consideration is given to the time of day and use made of occupied space in buildings; whether workshop, office, residential or a critical area. Tentative guidance is given on the magnitudes of vibration at which adverse comment may begin to arise. In cases where sensitive equipment or delicate tasks impose more stringent criteria than human comfort or annoyance, the corresponding more stringent values should be applied.

1 Scope

This British Standard provides general guidance on human exposure to building vibration in the frequency range 1 Hz to 80 Hz. Curves of equal annoyance for humans are included together with measurement methods to be employed.

Appendix A provides the best available information on the application of the weighting curves to different situations.

Appendix B provides guidance on vibration conditions which may cause adverse comment. Current methods of assessing continuous, intermittent and impulsive vibration are also presented in Appendix B. Blast induced vibration is addressed in Appendix C.

This British Standard does not provide guidance on the probability of structural damage to buildings or injury to occupants of buildings subject to vibration.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

2 Characteristics of building vibration

2.1 Direction of vibration

Because a building may be used for many activities, standing, sitting and lying may all occur. For example, vertical vibration of the building may enter the body as either x-axis, y-axis or z-axis vibration, as defined in Figure 1.

This standard distinguishes between these three axes of vibration, and normally the measured vibration should be referred to the appropriate axis.

2.2 Frequency weighting

There is evidence from research concerning the building environment to suggest that there are summation effects for vibration at different frequencies. Therefore, for the evaluation of building vibration with respect to annoyance and comfort, overall weighted values of the vibration are preferred.

2.3 Time history of vibration

Building vibrations as they affect people may be classified as impulsive or continuous as follows.

a) Impulsive vibration is a rapid build-up to a peak followed by a damped decay which may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, i.e. less than 2 s.

b) Continuous vibration is vibration which continues uninterrupted for either a day time period of 16 h or a night time period of 8 h, for example 23.00 h to 07.00 h.

In addition vibration may be intermittent. A procedure is described in Appendix B to relate the severity of intermittent vibration to that for continuous vibration.

3 Measurement of vibration

3.1 Introduction to the use of acceleration or particle velocity

In general, building vibration should be measured in acceleration terms. In some cases, such as impulsive events, it may be found convenient to measure in terms of particle velocity so that peak values may be identified.

A suitable technique is to record unfiltered time histories from which any desired value can later be determined, although it is acceptable to carry out field evaluation with appropriate instrumentation.

Performance characteristics for appropriate instrumentation for measuring acceleration can be obtained in BS 6841 and BS 7482-1 and BS 7482-3.

Guidance on general performance characteristics for current instrumentation to measure peak particle velocity is given in Appendix C.

3.2 Location for measurements

Measurements of vibration should normally be taken on a building structural surface supporting a human body. In some circumstances, measurements may have to be made outside the structure, or on some surface other than points of entry to the human subject. Where measurements are made other than at the point of entry of vibration to the body an allowance should be made for the transfer function between the measurement point and the point of entry to the body. It is essential that this allowance is specified by the investigator.

Preferably, measurements should be taken along the three orthogonal axes shown in Figure 1, and reference made to the appropriate curves of Figure 2 to Figure 7 for each axis of the human body.

If the orientation of the occupants with respect to the vibration environment is constant and known, the weighting functions established for the x, y, or z directions should be used. If the orientation of the occupants is varying or unknown with respect to the detected vibration, the weighted values should normally be obtained for all axes and the highest value used.

3.3 Information on evaluation criteria and procedures currently in use

Information on evaluation criteria and procedures currently in use are shown in Appendix A.

Current information on multiplying factors to be used with base curves to specify satisfactory magnitudes of building vibration to keep human response (annoyance, complaints) to acceptable levels are presented in Appendix A (see Table 5). The corresponding r.m.s. acceleration and particle peak velocity curves are given in Figure 4 to Figure 7.

NOTE It is recognized that the relation between r.m.s. acceleration and peak velocity depends upon the nature of the waveform. The curves for peak velocity are calculated assuming sinusoidal motion. The relationship between the weighted acceleration and the peak particle velocity is shown in Table 8.

3.4 Guidance on appropriate usage of acceleration assessment (with reference to Appendix A)

Vibration should be assessed on the basis of the vibration dose value (VDV) or the r.m.s. value of the frequency-weighted acceleration. Appendix B defines the appropriate procedures.

3.5 Guidance on appropriate usage of peak particle velocity assessment (with reference to Appendix A and Appendix C)

Where peak particle velocity records have been obtained for impulsive events, then the records can be treated as described in Appendix C for comparison with the guidance magnitudes given in Appendix A.

Continuous vibration records in terms of velocity can be assessed using the guidance contained in Appendix A.

Table 1 — Acceleration values for the base curve in Figure 2

Frequency	Acceleration (r.m.s.)
Hz	m/s ²
1	1.00×10^{-2}
1.25	8.94×10^{-3}
1.60	7.91×10^{-3}
2.00	7.07×10^{-3}
2.50	6.32×10^{-3}
3.15	5.63×10^{-3}
4.00	5.00×10^{-3}
5.00	5.00×10^{-3}
6.30	5.00×10^{-3}
8.00	5.00×10^{-3}
10.00	6.25×10^{-3}
12.50	7.81×10^{-3}
16.00	1.00×10^{-2}
20.00	1.25×10^{-2}
25.00	1.56×10^{-2}
31.50	1.97×10^{-2}
40.00	2.50×10^{-2}
50.00	3.13×10^{-2}
63.00	3.94×10^{-2}
80.00	5.00×10^{-2}

Table 2 — Acceleration values for the base curve in Figure 3

Frequency	Acceleration (r.m.s.)
Hz	m/s ²
1	3.57×10^{-3}
1.25	3.57×10^{-3}
1.60	3.57×10^{-3}
2.00	3.57×10^{-3}
2.50	4.46×10^{-3}
3.15	5.63×10^{-3}
4.00	7.14×10^{-3}
5.00	8.93×10^{-3}
6.30	1.13×10^{-2}
8.00	1.43×10^{-2}
10.00	1.79×10^{-2}
12.50	2.23×10^{-2}
16.00	2.86×10^{-2}
20.00	3.57×10^{-2}
25.00	4.46×10^{-2}
31.50	5.63×10^{-2}
40.00	7.14×10^{-2}
50.00	8.93×10^{-2}
63.00	1.13×10^{-1}
80.00	1.43×10^{-1}

Table 3 — Velocity (peak) values for the base curve (curve 1) in Figure 5

Frequency	Velocity (peak)
Hz	m/s
1	2.25×10^{-3}
1.25	1.61×10^{-3}
1.60	1.11×10^{-3}
2.00	7.96×10^{-4}
2.50	5.69×10^{-4}
3.15	4.02×10^{-4}
4.00	2.81×10^{-4}
5.00	2.25×10^{-4}
6.30	1.79×10^{-4}
8.00	} 1.41×10^{-4}
10.00	
12.50	
16.00	
20.00	
25.00	
31.50	
40.00	
50.00	
63.00	
80.00	