

BRITISH STANDARD

Guide to evaluation of human exposure to vibration in buildings

Part 2: Blast-induced vibration

ICS 13.160



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This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 17 and a back cover.

Foreword

Publishing information

This part of BS 6472 was published by BSI and came into effect on 30 June 2008. It was prepared by Subcommittee GME/21/6, *Human exposure to mechanical vibration and shock*, under the authority of Technical Committee GME/21, *Mechanical vibration, shock and condition monitoring*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

Together with BS 6472-1:2008 this part of BS 6472 supersedes BS 6472:1992, which is withdrawn.

Information about this document

This part of BS 6472 contains guidance on the assessment of human response to vibration not available in ISO 2631-2.

BS 6472-1 and BS 6272-2 contain additional guidance and take account of recent developments in the subject. The layout of the standards differs substantially from previous editions. These present versions are intended to be more logical and accessible in their presentation of human perception to vibration.

BS 6472-2 deals with the particular problems associated with periodic blasting within range of occupied buildings: the guidance is a formalization of established, widely recognized techniques common in industry. BS 6472-1 offers guidance on how people inside buildings respond to building vibration other than from blasting.

A bibliography of appropriate supporting data published elsewhere is included.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the following statutory regulations and guidance notes.

Control of Pollution Act 1974 [1]

Town and Country Planning Act 1990 [2]

Environmental Protection Act 1990 [3]

Minerals Planning Guidance Note MPG9 [4]

Minerals Planning Guidance Note MPG14 [5]

Planning Advice Note PAN50, Annex D [6]

Minerals Technical Advice Note, MTAN (Wales) 1: Aggregates [7]

1 Scope

This part of BS 6472 gives guidance on human exposure to blast-induced vibration in buildings. It is primarily applicable to blasting associated with mineral extraction. This part of BS 6472 might also be useful in assessing other forms of vibration that are caused by blasting, including when explosives are utilized in civil engineering works and in demolition activity. One-off explosive events such as bridge or building demolitions are outside the scope of this document.

This part of BS 6472 does not give guidance on the probability of equipment malfunction, building damage or injury to occupants in buildings subject to blast-induced vibration. Neither is guidance given on legal liability or vibration control and minimization. Advice on damage risk is given in BS 7385.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS 6841, *Guide to Measurement and evaluation of human exposure to whole-body mechanical vibration and repeated shock*

BS EN ISO 8041, *Human response to vibration – Measuring instrumentation*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 air overpressure

pressure wave in the atmosphere produced by a detonation of explosives

NOTE 1 Air overpressure consists of both audible (noise) and inaudible (concussion) energy.

NOTE 2 It is measured in pascals and usually reported in dB(lin).

3.2 data scatter

distribution of measured results

3.3 lapse rate

rate of fall of temperature with height

NOTE Lapse rate is measured in °C·km⁻¹.

3.4 maximum instantaneous charge (MIC)

maximum amount (kg) of explosive detonated on any one delay interval

NOTE A typical blast consists of a number of boreholes. It is usually the case that each borehole is detonated individually by the use of detonators at specific delay intervals.

3.5 scaled distance

slant distance between the blast and the receiver divided by the square root of the maximum instantaneous charge

NOTE Scaled distance is measured in $m \cdot kg^{-0.5}$.

3.6 slant distance

3-D vector distance between the blast location and measurement position obtained from coordinates in east-west, north-south and vertical directions

NOTE Slant distance is measured in metres (m).

4 Measurement and prediction of vibration

4.1 Characteristics of blast-induced vibration

Blast-induced vibration is impulsive in nature and a typical time history would be a rapid build-up to a peak followed by a decay which might or might not involve several cycles of vibration (depending on damping). In some cases, for example in some forms of underground mine blasting, there might be a number of such impulses in one blast vibration event.

The duration of an event at the point of measurement (typically one or two seconds) is dependent upon the magnitude of the blast, i.e. the number of delay intervals and explosive quantities, the method of detonation, separation distance and the intervening geology between the blast and the receiver.

A typical blast consists of a number of boreholes into which are placed the necessary explosive charges. It is usually the case that each borehole is detonated individually by the use of a series of detonators each with differing inherent millisecond delays.

Impulsive events, such as blast-induced vibration, are generally measured in terms of unfiltered time histories of three component particle velocities from which the peak values can be identified.

4.2 Measurement of vibration

For blasting, the current practice is to measure the peak particle velocity (ppv) using velocity transducers. Vibration measuring equipment or seismographs should be able typically to measure over the range $0.0001 \text{ m} \cdot \text{s}^{-1}$ ($0.1 \text{ mm} \cdot \text{s}^{-1}$) to $0.1 \text{ m} \cdot \text{s}^{-1}$ ($100 \text{ mm} \cdot \text{s}^{-1}$) over the frequency range 4.5 Hz to 250 Hz. Results obtained might differ slightly among sets of equipment.

Although velocity transducers are commonly used because they measure the desired parameters directly, other forms of instrumentation might be appropriate provided that the constant velocity characteristics can be derived.

The typical range of vibration frequency for blast-induced vibration is from 5 Hz to 40 Hz.

Usually in the case of blast-induced vibration, measurements should be made outside the building on a well-founded hard surface as close to the building as possible. Alternatively transducers may be buried if no such surface is available. Guidance on appropriate methods of mounting transducers is available elsewhere [8].

NOTE There might be occasions when measuring inside a property is necessary, for example, for public relations purposes.

Since this British Standard is concerned with human response within buildings, the external levels are set so as to achieve satisfactory internal levels.

Calibration of equipment and traceability are important but outside the scope of this standard.

4.3 Prediction of vibration

In order to predict the likely vibration magnitude, a series of measurements at several locations should be taken from one or more trial blasts. The vibration measuring equipment should be located in an approximate straight line in the propagation direction of interest. Depending on the number of directions of interest, the local geology and the availability of equipment, several trial blasts might be needed. Scaled distance graphs can then be prepared for each direction of interest. The ppv in the three translational axes should be measured in $\text{mm}\cdot\text{s}^{-1}$ and the maximum component of the vibration identified for each measurement location.

The values should then be plotted against scaled distance on logarithmic scales where the scaled distance, s , is as follows:

$$s = d / \sqrt{C}$$

Where:

d is the slant distance from the blast in m;

C is the MIC in kilograms.

A graph similar to that shown in Figure 1 should result, specific to each site under consideration. The graph can then be used to indicate the likely vibration magnitudes at a given distance for a given MIC.

Differing geology and changes in blast design [9] result in data scatter and this should be taken into account in determining an adequate number of data points. Vibration limits should be expressed as a statistical average to take account of the data scatter.

The scaled distance approach can be a great help in designing blasts to achieve specific magnitudes of vibration at specific locations.

EXAMPLE

If the ppv limit is to be $6 \text{ mm}\cdot\text{s}^{-1}$ for 90% of the blasts and the MIC is 100 kg then from Figure 1 it can be seen that the scaled distance value on the 90% line at $6 \text{ mm}\cdot\text{s}^{-1}$ is $65 \text{ m}\cdot\text{kg}^{-0.5}$. This means that the slant distance d can be deduced from the following equation

$$s = d / \sqrt{C}$$

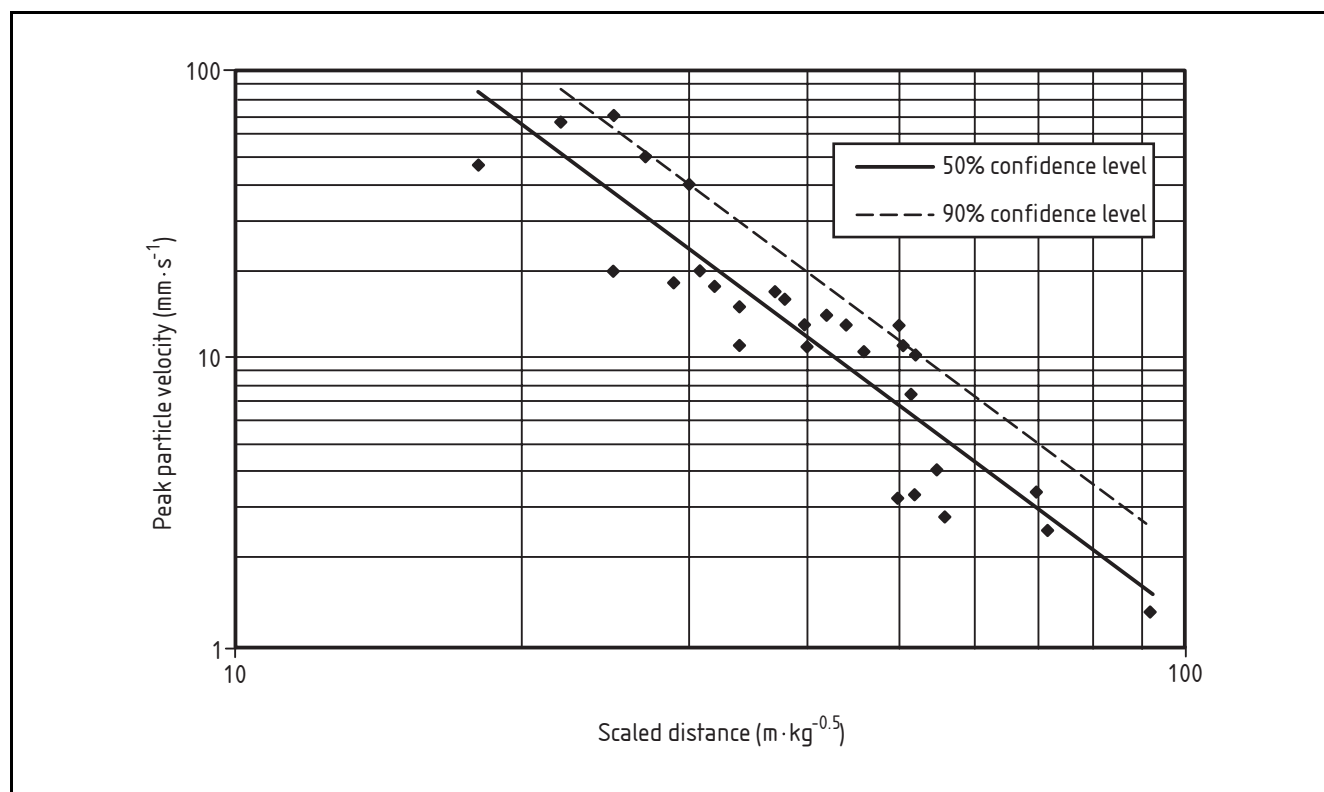
Where s is the scaled distance and C is the MIC.

Hence d is 650 m.

Similarly, if the vibration limit and slant distance are known then the MIC can be calculated.

The scaled distance data should be kept under regular review as blast monitoring continues through the operation of the site and the data set increases.

Figure 1 Site-specific scaled distance graph



5 Measurement and prediction of air overpressure

5.1 General

Whenever blasting is carried out energy is transmitted from the blast site in the form of airborne pressure waves. These pressure waves comprise energy over a wide range of frequencies, some of which are at frequencies higher than 20 Hz and are, therefore, perceived as sound. The majority of the airborne energy is carried at frequencies below 20 Hz and hence is inaudible to the human ear, but can be sensed as concussion or pressure. It is the combination of the sound and concussion that is known as air overpressure.

Any attenuation due to the topography, either natural or man-made, between the blast and the receiver is much greater for the audible higher frequency components of the pressure wave, with the lower frequency components being largely unaffected. The amount of energy transmitted in the audible part is relatively small compared with that transmitted in the inaudible part. Baffles, mounds and other acoustic screening techniques do not significantly reduce air overpressure levels.