



Aldridge Piling Equipment (Hire) Co Ltd  
[www.miniape.com](http://www.miniape.com)



## Vibration Information

Tel. 01543 277680 Fax. 01543 270090  
email [Hire@miniape.com](mailto:Hire@miniape.com)



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### Piling Vibration

Piling using an impact or vibrator will generate ground vibrations, the magnitude of the vibration being greatest close to the pile. The frequency, duration and magnitude of vibration varies depending on distinct hammer types, human perception, proximity to neighbours and ground conditions.

It is possible to estimate likely levels of ground vibration using empirical methods, these are relatively conservative and will assist with arranging a Prior Consent Agreement for the works. Frequency of the input vibration is important to avoid resonance, a phenomenon at which vibration introduced has the greatest effect on soil and neighbouring buildings.

Potential problems caused by ground vibrations can be alleviated or eliminated by:

- o pre-contract planning, to obtain a Consent to Work Agreement.
- o selecting the most appropriate pile driver and working method,
- o forewarning residents of the forthcoming work and its duration and assuring them of the very low risk of damage to property,
- o carrying out property surveys, before and after work.

### Equipment Overview

You must evaluate if you have a potential vibration problem and address the appropriate standards. All piling equipment, that performs its function by production of impact or vibration, will introduce ground vibrations into the environment.

Equipment must be selected that suits the location of piling. Theoretically, there is often little difference observed between impact and vibratory hammers. Practical experience has shown a perception of lower levels of ground vibration using impact hammers in comparison to vibrators. Also that the vibration produced by impact hammers is less likely to result in compaction or settlement of ground, which can undermine a buildings' structure.

In highly sensitive locations, very close to existing structures or historic buildings, pile press systems are recommended as they produce no ground vibration. Attention must be paid to the use of water jetting equipment

There is a wide range of available vibrators, used most effectively in granular soils, and to a lesser extent in clays and silts. Selection of a high frequency or resonant frequency vibrator will lead to fast attenuation of ground vibrations produced, minimising disturbance and avoiding potential resonance.

A recent development in vibratory equipment, further advances control through the incorporation of automatic control of vibration output, to ensure that ground vibrations - as measured by suitable sensors - does not exceed predetermined levels.

For driving into stiff, cohesive soils, an impact hammer may be needed. Vibration can be minimised through using a controllable hydraulic hammer, or in instances where nuisance is the main concern an impact hammer will serve to reduce the duration of exposure.



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British Standards are not legal requirements, but in many instances they are a Code of Practice. Like any approved code of practice, failure to follow, can lead to serious consequences including, site delays and general inconvenience; grounds for prosecution under existing legislation, most of which requires the best practical means to be used, especially where safety aspects are concerned.

The implications of British and European standards can be felt on a daily basis. Those that pertain to physical agents are most frequently encountered through their adoption within the Control of Pollution Act 1974. **Sections 57, 58 & 59** of the Act refer to noise in general, with **Section 60**, referring to construction sites, enabling the local authority to impose controls or to specify equipment to be used, hours of work and noise levels during any specified hours. **Section 71**, of the Act, refers to codes of practice for minimising noise, with **Section 72**, introducing the term 'best practicable means' applicable to all construction activities covered by the Act.

The definition of best practicable means taking into consideration local conditions and circumstances, the current state of technical knowledge and also financial implications. For the purpose of application, noise and vibration are often considered the same type of pollution. Therefore, this Act gives to local authorities powers to enforce their requirements for the control of noise and vibration.

Any site that has not consulted the local authority with regards to methods employed can, at the discretion of the local authority, be served with a notice under section 60 of the Control of Pollution Act 1974. The notice being an enforcement of all the discretionary powers, as provided for local authorities in the Act. In serving such a notice, the local authority will take account of any code of practice issued or approved; the need for ensuring that the best practicable means has been employed; the use of other equipment, when equally as effective in efforts to reduce noise and vibration; the need to protect people in the neighbourhood against the effects of such physical agents.

The preferred means of control is through **Prior Consent**. This also falls under section 60 of the Control of Pollution Act 1974. It is the preferred approach as it is less adversarial, the contractor having taken the initiative and sought a consent to the proposed methodology. This will typically lead to a **Consent to Work Agreement**. The basic layout and severity can vary substantially throughout the country and it is not surprising to obtain an agreement which states that earthworks should use the best practice means to reduce noise and vibration at all times having regard to BS 5228.

Further due to the range of related standards dealing with these physical agents, it is common for such prior consents to state a wide range of standards under section 71 of the Act. This can result in a degree of conflict, since many will start with the guidance of BS5228, but then apply more stringent requirements as introduced by other standards. It is essential that an application for a consent is made at the same time as any request under Building Regulations.

Consent to Work Agreements whilst variable amongst local authorities, will typically be of a standard nature and so will not always relate to the individual nature of many construction sites. Also when shoring is considered aside from piling, there is a clear void in the availability of equipment as illustrated in Chapter 3. This in turn makes void certain parts of standards such as BS 5228, which recommend alternative techniques, which in examination are not available for shoring applications or rather applications that would use proprietary shoring systems.



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In an example prior consent, the requirements progressively became more stringent, exceeding levels stated in any British Standard. Local authorities must refrain from adding unsubstantiated clauses. When limits are expressed within British Standards, they typically refer to the power of the equipment, which in turn can be related back to a specific maximum size of hammer. When clauses are applied to a generic range of equipment such as impact hammers or vibratory equipment, then there is little room to manoeuvre.

If the contractor has been proactive enough to seek a prior consent from their local authority, attention must be made to ensure that the agreed site conditions set, can be abided to by the contractor.

Due to the provisions for influence of local environmental conditions and also cost, discussion with local authorities can lead to easing of site restrictions. Indeed BS 5228 does state that a flexible approach and appreciation of techniques is required. Even when a quieter option is available its adoption may lead to the prolonging of the piling process; the net result increasing the overall disturbance to the neighbouring community. This is compounded by BS6472 which notes that higher limits may be required for piling operations, to avoid unduly prolonging the overall disruption to neighbouring occupants.

### BS 5228 Part 4: 1992

#### Noise control on construction and open sites - Part 4 Code of Practice for noise and vibration applicable to piling applications

Typically the main use for this British Standard, is vibration level prediction and control. Vibration levels produced by piling equipment are most frequently a consideration when working near buildings. This is especially true in the case of shoring applications which typically are based in closer proximity to neighbouring buildings.

The inherent problem of BS5228 occurs as the 'whole' Piling Industry is considered, and that the solutions presented, especially those which recommend alternate techniques, typically fall outside the scope of this document and rarely address options available with proprietary shoring equipment.

### Section 3 - Vibration

Vibration prediction is not an exact science, since soil type greatly affects the transmission of the vibration. Therefore all predictions should ideally be verified by appropriate field measurement.

BS5228 states

Building Type	No Cosmetic Damage
Max PPV below 50Hz	
Ruins and buildings of architectural merit	2mm/sec
Residential	5mm/sec
Light Commercial	10mm/sec
Heavy Industrial	15mm/sec

**Eurocode 3 (1998).**

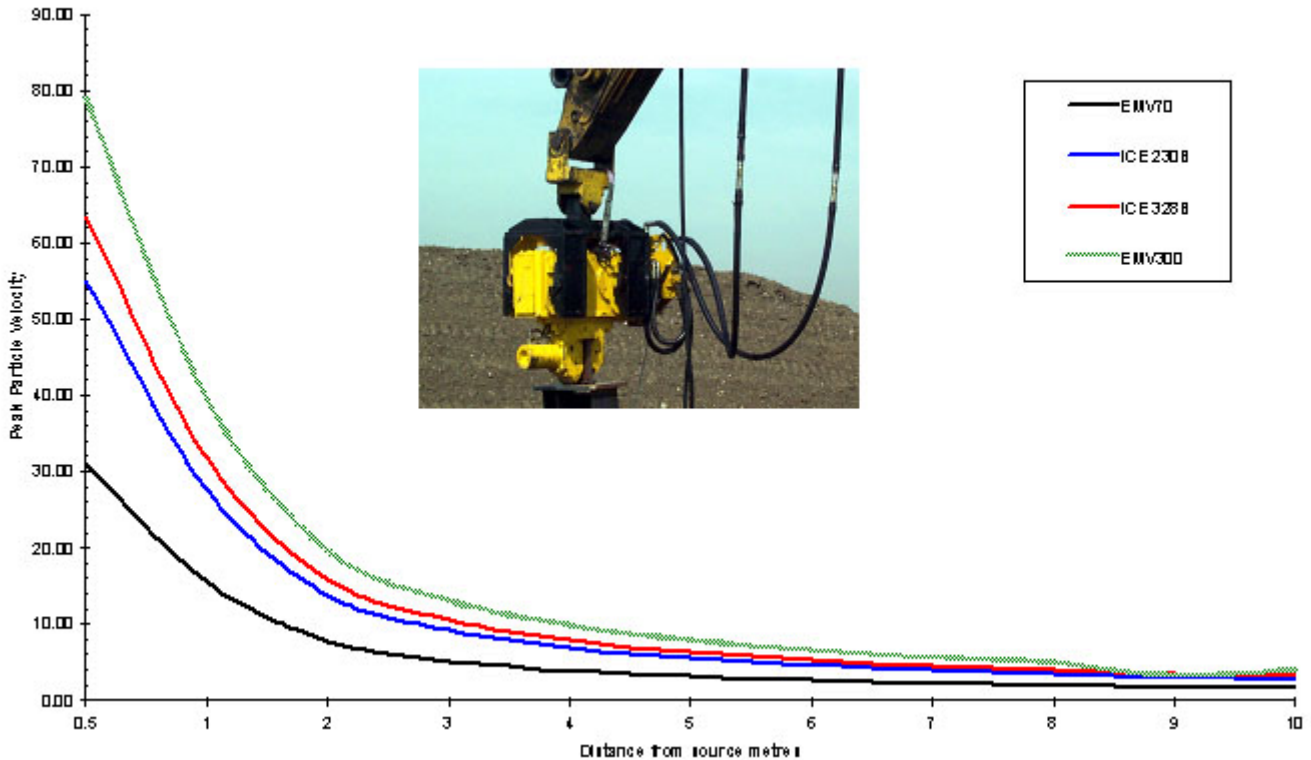
Type of property	Peak particle velocity mm/s	
	Continuous vibration	Transient vibrations
Ruins, buildings of architectural merit	2	4
Residential	5	10
Light commercial	10	20
Heavy Industrial	15	30
Buried services	25	40



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Theoretical Peak Particle Velocity for typical excavator mounted vibrators



## BS7385-1:1990 (ISO 4866)

### Evaluation and measurement of vibrations and evaluations of their effect in buildings

#### Part 1: Guide for measurement of vibrations and evaluation of their effect on buildings.

##### Introduction

Like BS5228, this standard relates to ground vibrations. Part 1 is from the perspective of identifying factors which make buildings prone to damage caused by vibration. These features being used to assist in the classification of building types. This understanding being important to ensure that all new building designs are capable of withstanding set magnitudes of vibration and also with the methodologies to ensure correct measurement of vibration in preservation efforts on existing and historic building types.

Part 1 of this standard does not state limits, these can be found in Part 2 of this standard. Further, this standard is not application specific and does not consider the sources of vibration in any detail other than discrete specifications which may influence the effect of vibration on the structure, for example frequency.

This Standard establishes the basic principles for carrying out vibration measurement and processing data, with regards to evaluating vibration effects on buildings. A building, is defined as any above ground structure, which man frequently inhabits. This excluding structures which may be visited from time to time by operating staff.



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The structural response of buildings depends upon the excitation; this standard therefore examines the methods of measurements as affected by the source. i.e. frequency, duration, and amplitude as induced by any source, such as earthquakes, explosions, wind effects, sonic booms, internal machinery, construction activities such as piling, and influence of traffic (road or rail).

### BS 7385-2:1993 (ISO 4866)

#### Evaluation and measurement for vibration in buildings -

##### Part 2: Guide to damage levels from groundbourne vibration.

This Part of BS 7385 provides guidance on the assessment of the possibility of vibration-induced damage in buildings due to a variety of sources. The impetus for this Part standard being, to identify whether damage can occur, what kind of damage and at what levels, to alleviate any concern arising from man-made sources of vibration.

**This Part of BS 7385 sets guide values for buildings vibration based on the lowest vibration levels above which damage has been credibly demonstrated.** Case history data, taken alone, has been stated as being inadequate for identifying thresholds. The values stated within this standard relating to controlled vibration studies in the vicinity of buildings.

The indirect effects on the building due to ground movement, the movement of loose objects within buildings, the possibility of damage to sensitive equipment and the effect of vibration on people are outside the scope of BS7385. Annex C does however provide an informative guide to building damage caused by soil compaction

Levels provided here being substantially higher than those found in BS 6472 (as described later), since there is a major difference between the sensitivity of people to vibration and that required to initiate or cause damage.

Type of Building	Peak component particle velocity in frequency range of predominant pulse	
	4Hz to 15Hz	15Hz and above
Reinforced or framed structures. Industrial and heavy commercial buildings	50 mm/s at 4Hz and above	
Unreinforced or light framed structures Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15 Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above



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## BS 6472:1992 Guide to Evaluation of human exposure to vibration in buildings (1Hz to 80 Hz)

This provides guidance on human response to building vibration which can be detected by occupants and can affect them in various ways. Tentative guidance is given on vibration magnitudes at which adverse comment may arise. **This is the most common standard used for environmental assessment.**

Because buildings may be used for many activities, occupants inside can be found in a variety of body postures - standing, sitting and lying down. In these different postures, the response to vibration varies quantitatively according to the direction in which it is perceived. Generally, vibrations in the **foot-to-head** mode (z axis) are more perceptible than those in the **back-to-chest** (x- axis) or **side-to-side** (y-axis) modes. Although at very low frequency this tendency is reversed. BS5228, makes mention to triaxial measurement, but its predictive methods place more prominence on peak particle velocity.

When the likely posture of the occupants is known then the axis pertaining to that position should be the one measured, estimated and stated. When the likely postures are unknown, all axes should be estimated or measured and the axis with the highest dose value should be stated.

Another difference from BS5228 is that when considering human exposure to vibration, it is common for these levels to be frequency weighted in a similar way to A-weighting of noise.

Dosage is typically stated in terms of  $m/s^{0.75}$ . This value is calculated using measured values of frequency weighted accelerations. This is as opposed to peak particle velocity, which is most likely the term used to describe vibration from piling operations. This standard states a ratio of 2.8, to convert ppv to acceleration (r.m.s.) as shown in Table 8 of BS6472. This enables the dose to be calculated from both the actual measured values and those obtained through the prediction method outlined in BS5228.

**Relationship between PPV, acceleration r.m.s (Z axis - head to toe) and dose**

Std	Key	SDON Distance (m) permissible to attain stated ppv (BS 5228 pt 6)	ENV300 Distance (m) permissible to attain stated ppv (BS 5228 pt 6)	Peak Particle velocity	Frequency weighted r.m.s acceleration	Daytime Residential				Nighttime Residential		
						Estimated Vibration Dose 16hr	Estimated Vibration Dose 8 hr	Estimated Vibration Dose 4hr	Estimated Vibration Dose 2hr	Estimated Vibration Dose 8 hr	Estimated Vibration Dose 4hr	Estimated Vibration Dose 2hr
BS 6472	Low probability of adverse comment	301.66	395.00	0.10	0.0035	0.077	0.065	0.054	0.046	0.992	0.834	0.701
		201.10	263.33	0.15	0.0053	0.115	0.097	0.082	0.069	1.488	1.251	1.052
BS 6472	Adverse comment possible	150.83	197.50	0.20	0.0071	0.154	0.129	0.109	0.091	1.984	1.668	1.403
BS 6472	Adverse comment probable	120.66	158.00	0.25	0.0089	0.192	0.162	0.136	0.114	2.480	2.085	1.753
		100.55	131.67	0.30	0.0106	0.231	0.194	0.163	0.137	2.976	2.502	2.104
		75.41	98.75	0.40	0.0142	0.308	0.259	0.218	0.183	3.967	3.336	2.805
		60.33	79.00	0.50	0.0177	0.385	0.323	0.272	0.229	4.959	4.170	3.507
		50.28	65.83	0.60	0.0213	0.461	0.388	0.326	0.274	5.951	5.004	4.208
		43.09	56.43	0.70	0.0248	0.538	0.453	0.381	0.320	6.943	5.838	4.909
		37.71	49.38	0.80	0.0284	0.615	0.517	0.435	0.366	7.935	6.672	5.611
		33.52	43.89	0.90	0.0319	0.692	0.582	0.489	0.412	8.927	7.506	6.312
		30.17	39.50	1.00	0.0355	0.769	0.647	0.544	0.457	9.918	8.340	7.013
BS5228	Rules	15.08	19.75	2.00	0.0709	1.538	1.293	1.088	0.915	19.837	16.681	14.027
BS5228	Residential	6.03	7.90	5.00	0.1773	3.846	3.234	2.719	2.287	49.592	41.702	35.067
BS5228	Light Commercial	3.02	3.95	10.00	0.3546	7.691	6.467	5.436	4.573	99.185	83.404	70.134
BS5228	Heavy Industrial	2.01	2.63	15.00	0.5319	11.537	9.701	8.188	6.860	148.777	125.105	105.202