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ANC Guidelines

A review of the guidance on groundborne noise and vibration assessment criteria

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- Building damage risk
- Human perception – health and wellbeing
- Groundborne noise
- Museums and galleries
- Sensitive equipment and processes

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Building damage risk



Groundborne noise and vibration assessment criteria

Building damage risk

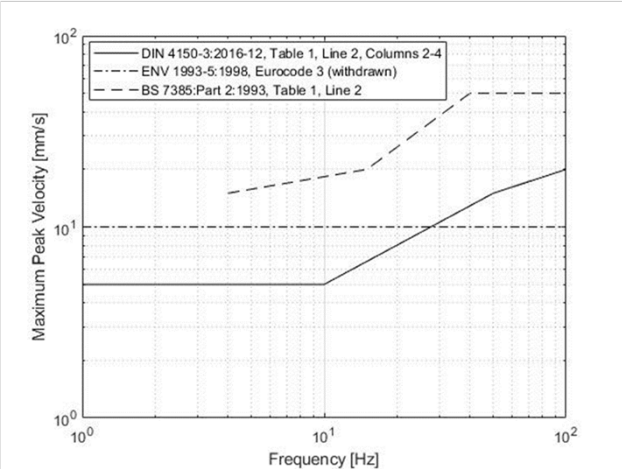


Figure 8.1 Transient (short-term) vibration damage thresholds for residential buildings

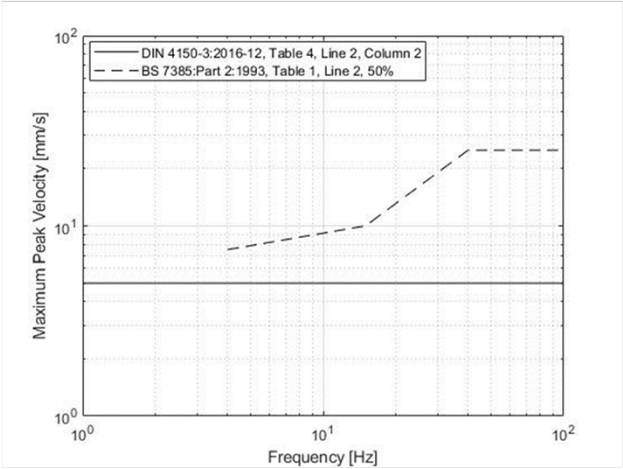


Figure 8.2 Continuous (long-term) vibration damage thresholds for residential buildings

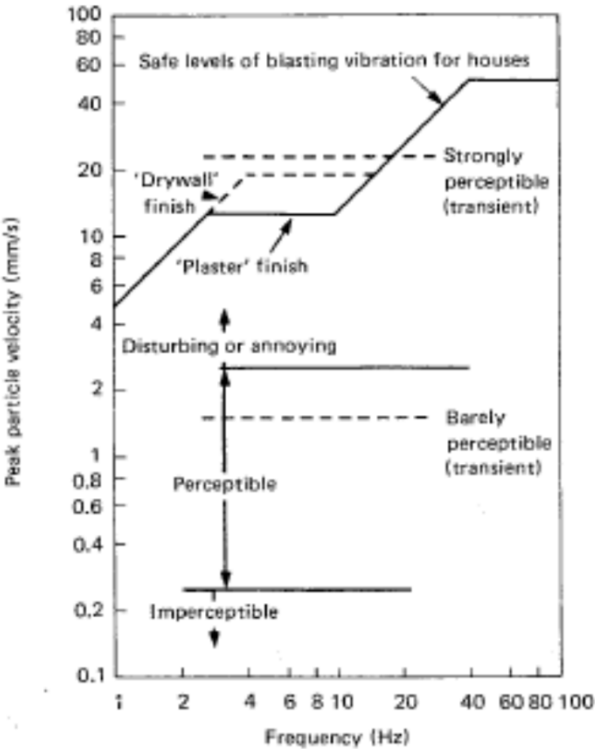


Fig.2 Safe blasting and human perception vibration thresholds

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Building damage risk

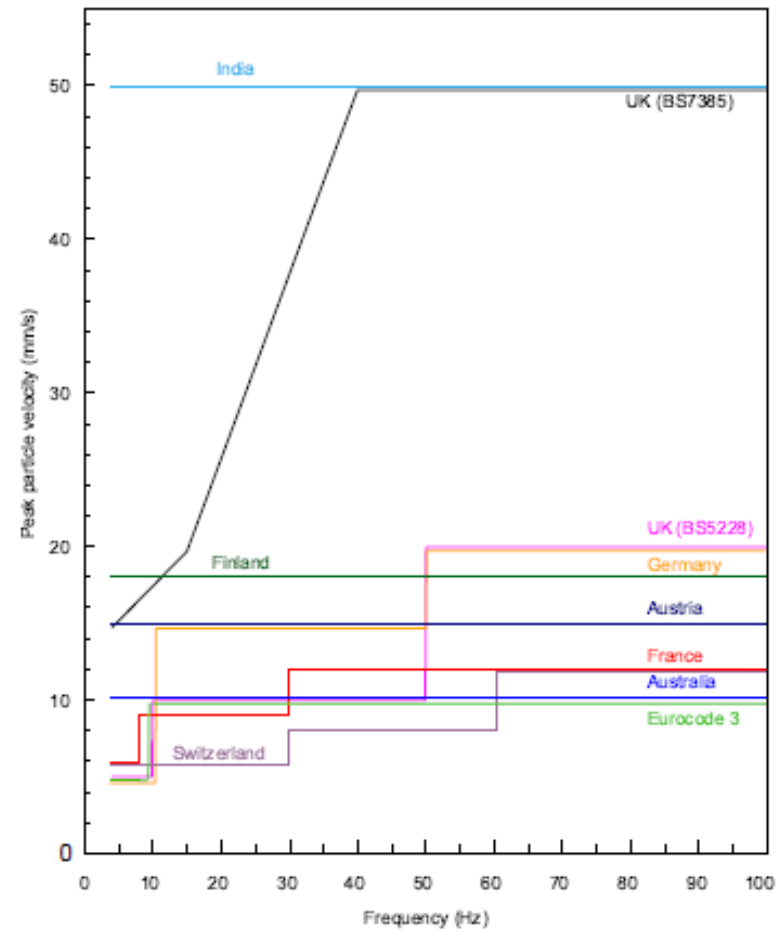


Figure 5 Summary of damage thresholds for transient vibration on domestic structures

Groundborne noise and vibration assessment criteria

What about old buildings?

Old \neq vulnerable

Treat with caution and due consideration



7.5.2 Important buildings

Important buildings which are difficult to repair may require special consideration on a case-by-case basis. A building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive.

Human perception: health and wellbeing

What do the aims of the Noise Policy Statement for England mean?

2.19 There are several key phrases within the NPSE aims and these are discussed below.

“Significant adverse” and “adverse”

2.20 There are two established concepts from toxicology that are currently being applied to noise impacts, for example, by the World Health Organisation. They are:

NOEL – No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL – Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

2.21 Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.

SOAEL – Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

2.22 It is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. It is acknowledged that further research is required to increase our understanding of what may constitute a significant adverse impact on health and quality of life from noise. However, not having specific SOAEL values in the NPSE provides the necessary policy flexibility until further evidence and suitable guidance is available.

Groundborne noise and vibration assessment criteria

Human perception: health and wellbeing

- Vibration – section 6.4

Threshold (residential)	VDV day ($\text{ms}^{-1.75}$)	VDV night ($\text{ms}^{-1.75}$)
LOAEL	0.2	0.1
SOAEL	0.8	0.4

Table 6.1. Suggested vibration dose values for the assessment of potential health effects inside residential dwellings

- Groundborne noise – section 7.2
 - LOAEL $35\text{dBL}_{\text{Amax,S}}$
 - SOAEL $45\text{dBL}_{\text{Amax,S}}$
- Ref to App I for example criteria and L/SOAELs

Groundborne noise and vibration assessment criteria

Perception and response criteria in terms of PPV

Table B.1 Guidance on effects of vibration levels

Vibration level ^{A), B), C)}	Effect
0.14 mm·s ⁻¹	Vibration might be just perceptible in the most sensitive situations for most vibration frequencies associated with construction. At lower frequencies, people are less sensitive to vibration.
0.3 mm·s ⁻¹	Vibration might be just perceptible in residential environments.
1.0 mm·s ⁻¹	It is likely that vibration of this level in residential environments will cause complaint, but can be tolerated if prior warning and explanation has been given to residents.
10 mm·s ⁻¹	Vibration is likely to be intolerable for any more than a very brief exposure to this level A₁ in most building environments A₁ .

A₁

A) The magnitudes of the values presented apply to a measurement position that is representative of the point of entry into the recipient.

B) A transfer function (which relates an external level to an internal level) needs to be applied if only external measurements are available.

C) Single or infrequent occurrences of these levels do not necessarily correspond to the stated effect in every case. The values are provided to give an initial indication of potential effects, and where these values are routinely measured or expected then an assessment in accordance with BS 6472-1 or -2, and/or other available guidance, might be appropriate to determine whether the time varying exposure is likely to give rise to any degree of adverse comment. **A₁**



Groundborne noise and vibration assessment criteria

Perception and response criteria in terms of PPV

Maximum satisfactory magnitudes of vibration with respect to human response for up to three blast vibration events per day

Place	Time	Satisfactory magnitude ^{A)} ppv mm·s ⁻¹
Residential	Day ^{D)}	6.0 to 10.0 ^{C)}
	Night ^{D)}	2.0
	Other times ^{D)}	4.5
Offices ^{B)}	Any time	14.0
Workshops ^{B)}	Any time	14.0

NOTE 1 This table recommends magnitudes of vibration below which the probability of adverse comment is low (noise caused by any structural vibration is not considered).

NOTE 2 Doubling the suggested vibration magnitudes could result in adverse comment and this will increase significantly if the magnitudes are quadrupled.

NOTE 3 For more than three occurrences of vibrations per day see the further multiplication factor in 5.2.

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Groundborne noise and vibration assessment criteria

Groundborne noise



Groundborne noise and vibration assessment criteria

Groundborne noise

- APTA 1981 – earliest criteria for GBN?

<i>Community area</i>	<i>Maximum groundborne noise level design goal (dB(A))</i>		
	<i>Single family dwelling</i>	<i>Multi family dwelling</i>	<i>Hotel /motel buildings</i>
Low density residential	30	35	40
Average density residential	35	40	45
High density residential	35	40	45
Commercial	40	45	50
Industrial/highway	40	45	55

Groundborne noise and vibration assessment criteria

Groundborne noise

- Ref to App H for example criteria – GBN all very similar to APTA 1981
 - What parameter?
 - $L_{Amax,S}$ most commonly used
 - $L_{Amax,F}$ Northern Line Extension, Crossrail 2
 - $L_{Amax,F}$ for offices in BCO 2009 but BCO 2019 uses $L_{Amax,S}$ (refers to the Red Book!)
 - Appendix H also provides project examples covering non-residential uses.



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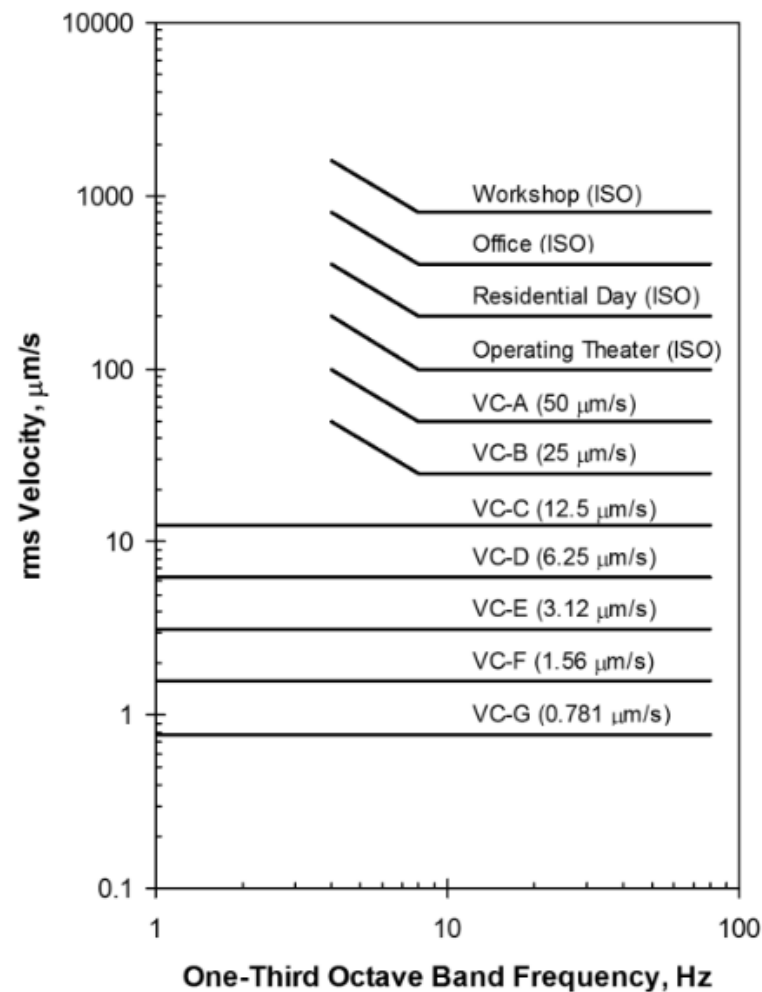
Groundborne noise and vibration assessment criteria

Sensitive equipment



Groundborne noise and vibration assessment criteria

Sensitive equipment – vibration criterion curves



Criterion Curve	Velocity ¹ μm/sec	Description of Use
Workshop (ISO)	800	Distinctly perceptible vibration. Appropriate to workshops and non-sensitive areas.
Office (ISO)	400	Perceptible vibration. Appropriate to offices and non-sensitive areas
Residential Day (ISO)	200	Barely perceptible vibration. Appropriate for sleep areas. Usually adequate for computer equipment, probe test equipment and microscopes less than 40X.
Operating Theatre (ISO)	100	Vibration not perceptible. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A	50	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	Appropriate for inspection and lithography equipment (including steppers) to 3 μm line-widths.
VC-C	12.5	Appropriate standard for optical microscopes to 1000X, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1A good standard for most lithography and inspection equipment to 1 μm detail size.
VC-D	6.25	Suitable in most instances for demanding equipment including many electron microscopes (SEMs and TEMs) and E-Beam systems.
VC-E	3.12	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, electron-beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	1.56	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for characterization.
VC-G	0.781	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for characterization.

1. As measured in one-third octave bands of frequency over the frequency range 8-80Hz (VC-A and VC-B) or 1 to 80Hz (VC-C through VC-G).

2. The detail size refers to line width in the case of microelectronics fabrication, the particle (cell) size in the case of medical and pharmaceutical research, etc. Detail size is not relevant to imaging associated with probe technologies, AFMs, and nanotechnology.

Groundborne noise and vibration assessment criteria

Sensitive equipment – NIST criteria

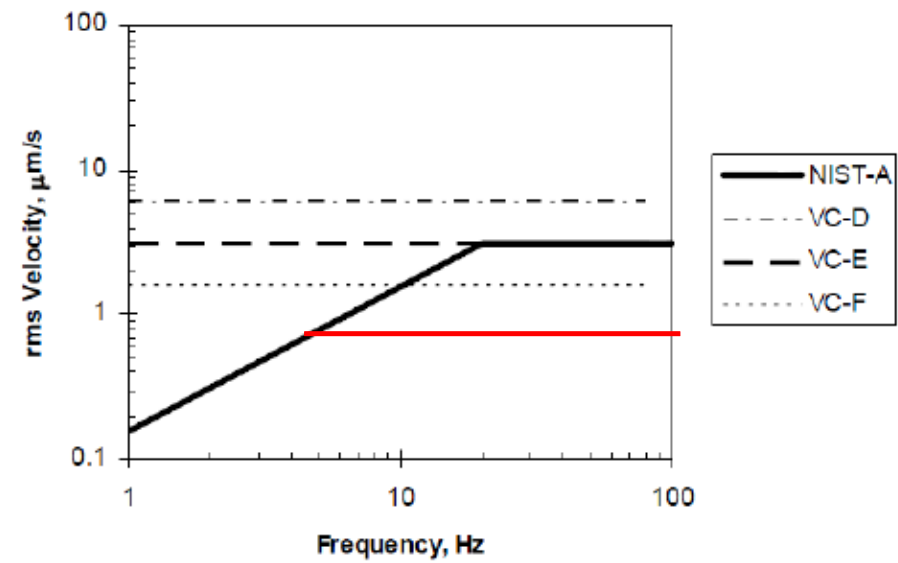


Figure 9.2 Graphical Definition of NIST-A Vibration Criterion Curve [56]

But what does it all mean, in practice?

- Over what period of time is the rms velocity analysed?
- For transient events over a time period, should the average, worst case, or a percentile value be used?
- How should the 1/3 octave band levels be derived, using digital filters or by processing from narrow band FFT data?
- What time weighting should be applied?
- At which location or locations should the specification be set?
- Is the frequency spectrum evaluated for an event peak hold or maximum RMS value, linear average, the average spectrum for the highest overall magnitude of vibration etc.?

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Museums and galleries



- See section 5.4
- Vulnerability and means of display are very variable, so individual assessment is needed
- Old ≠ vulnerable
- British Museum guidance – to prevent objects ‘walking’ on shelves:
 - General: PPV 0.1mm/s or 0.07mm/s 1/3 octave RMS velocity
 - During construction: 2 actions levels:
 - 1st level: 0.1mm/s PPV continuous; 0.3mm/s PPV intermittent
 - 2nd level: 0.3mm/s PPV continuous; 0.6mm/s PPV intermittent

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Museums and galleries



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Museums and galleries

- For paintings concern is about cracking or flaking of paint
- Several papers referenced in relation to vibration in transit
- In transit, although they are protected from flexing etc, they can experience sustained high vibration
- In practice, the evidence suggests that other concerns are likely to limit vibration before paintings become vulnerable



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Concluding remarks