HILSON MORAN

consulting engineers

Wellcome Trust

Bentley House, 200 Euston Road, London

Train Vibration Survey Report

Issue	Date
1.0	21 May 2010

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engineering the future
for the built environment

Wellcome Trust

Bentley House, 200 Euston Road, London

Train Vibration Survey Report

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Contents

1 EXECUTIVE SUMMARY

A planning application for a new development, comprising a student Hall of Residence and associated amenity areas, is proposed at Bentley House, 200 Euston Road, London. London Underground Lines run beneath Euston Road to the South of the site, and also to the North-West of the site. Subsequently, the potential exists for vibration and re-radiated noise due to underground trains to be perceptible in the new development.

Hilson Moran has therefore undertaken a vibration survey to determine the level of vibration affecting the current site to enable predictions of vibration and re-radiated noise in the proposed development to be undertaken.

The measured vibration levels due to underground trains were found to be of satisfactory magnitudes at various positions around the site. In addition, the estimated Vibration Dose Values (e.V.D.V's) determined for daytime and night-time periods were found to be less than the limits presented within Camden Borough Council's UDP.

Predicted worst-case (maximum) levels of re-radiated noise, due to underground trains, in the proposed bedrooms are predicted to be equal to or less than Camden Borough Council's typical standards.

2 INTRODUCTION

A Planning application for a new development, comprising a student Hall of Residence and associated amenity areas, is proposed at Bentley House, 200 Euston Road, London. London Underground Lines run beneath Euston Road to the South of the site, and also to the North-West of the site. Subsequently, the potential exists for vibration and re-radiated noise due to underground trains to be perceptible in the new development.

Hilson Moran has been appointed to undertake a vibration survey to determine the level of vibration affecting the current site due to underground train movements, so that predictions of vibration and re-radiated noise in the proposed development can be undertaken.

Following this introductory section, a description of the existing site is given in Section 3. Acceptability criteria for noise and vibration in the proposed development are proposed in Section 4. The vibration survey methodology is described in Section 5 with results and observations presented in Section 6 and Appendix B. Vibration and re-radiated noise levels are predicted in Section 7.

Appendix A presents an explanation of the noise and vibration terminology used in this report.

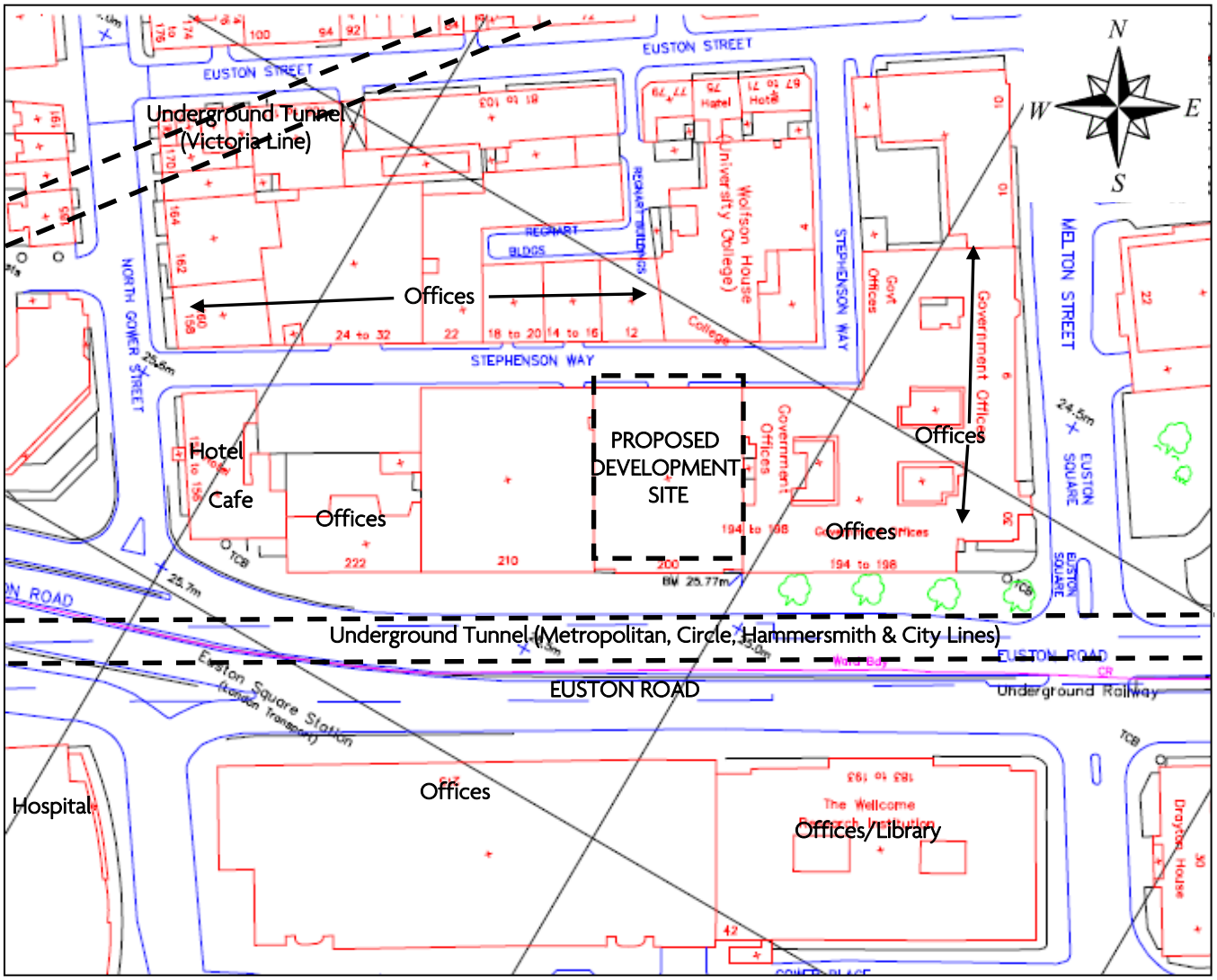
3 SITE DESCRIPTION

The proposed development site is located at 200 Euston Road in London. The site is currently occupied by Bentley House, a vacant 4-storey storage/archive building. Bentley House is bounded by Euston Road to the South, Stephenson Way to the North and office buildings to the East and West.

A London Underground Tunnel (carrying the Metropolitan, Circle and Hammersmith & City Underground lines) runs beneath Euston Road to the South of the site. In addition, a further London Underground Tunnel (carrying the Victoria Underground line) lies to the North-West of the site

Figure 3.1 below shows the existing site and its surroundings, as well as the approximate locations of the underground tunnels.

Figure 3.1 Location of Proposed Development Site and Surrounding Land Use



4 VIBRATION AND RE-RADIATED NOISE CRITERIA

Since vibration may be perceived not only directly as tactile vibration, but also as re-radiated noise, criteria for each should be considered.

4.1 Vibration

Table 4.1 shows Camden Council's typical standards relating to vibration levels on sites adjoining railways or roads at which planning permission will not be granted.[1]

Table 4.1 Vibration Levels on Sites Adjoining Railways or Roads at which Planning Permission will Not be Granted

Vibration Description and location of measurement	Period	Time	Vibration dose values ($m/s^{1.75}$)
Vibration inside dwellings	Day and Evening	07:00 – 23:00	0.2 to 0.4
	Night	23:00 – 07:00	0.13

4.2 Re-radiated Noise

Re-radiated noise is of greatest concern when it is the dominant noise, and also when the source cannot be seen. Criteria for re-radiated noise are therefore generally intended to apply to sources such as underground trains.

We understand that Camden Council has the following typical standard with regard to re-radiated noise levels in new *residential* developments[3]:

"Where dwellings may be affected by ground-borne regenerated noise internally from, for example, railways or underground trains with tunnels, noise levels within the rooms should not be greater than 35 dB(A)max."

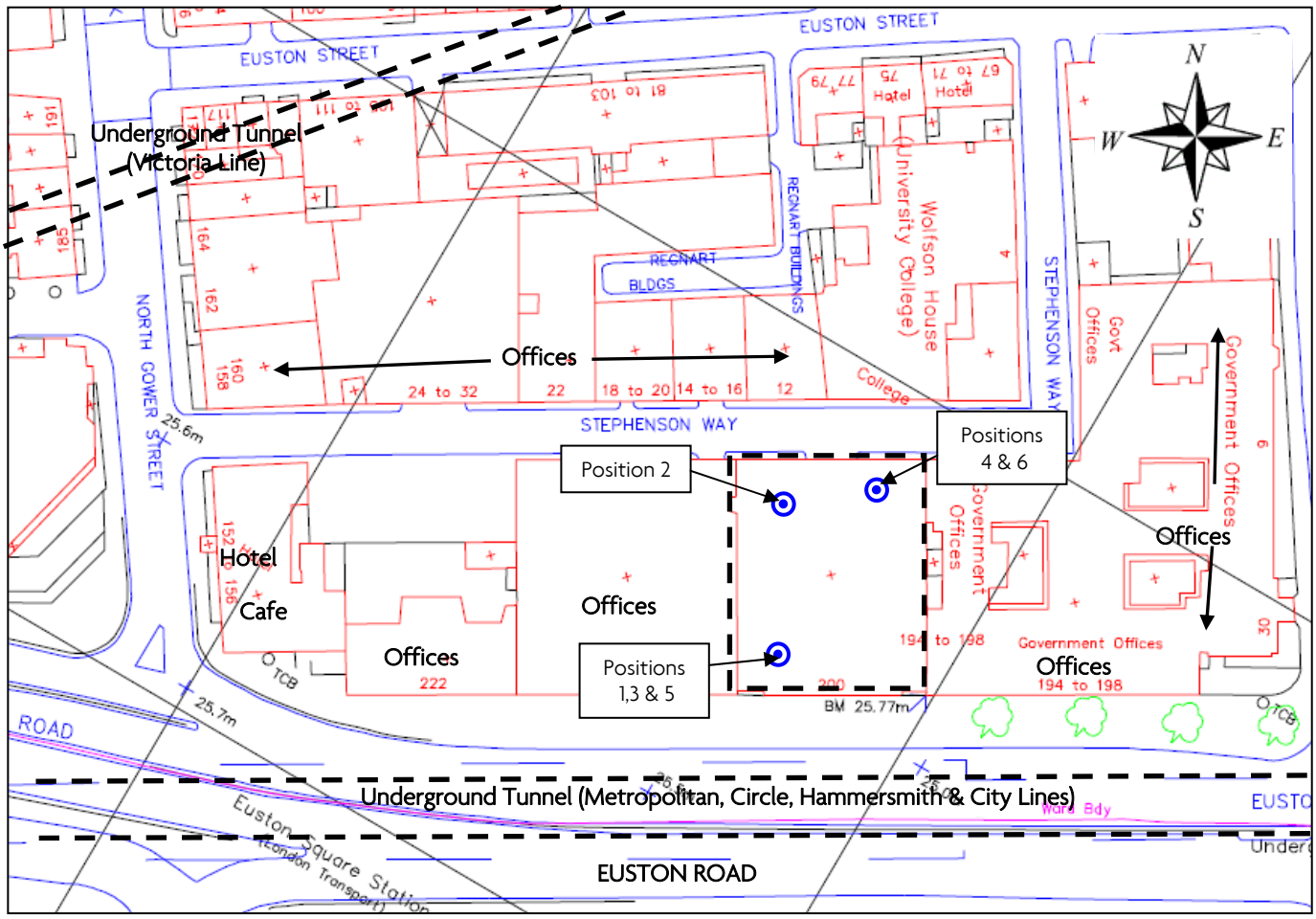
5 VIBRATION SURVEY METHODOLOGY

Manned vibration measurements were undertaken at six positions within Bentley House between approximately 11:00 and 14:30 hours on Friday 16 April 2010. The measurements positions are described in Table 5.1 and indicated in Figure 5.1.

Table 5.1 Description of Vibration Measurement Positions

Position	Location
1	Within the lift lobby towards the Southwest corner of the Basement of Bentley House,
2	Within the lift lobby towards the Northwest corner of the Basement of Bentley House,
3	Within the book store towards the Southwest corner of the Ground Floor of Bentley House
4	Within the book store towards the Northeast corner of the Ground Floor of Bentley House
5	Within the gents toilets towards the Southwest corner of the First Floor of Bentley House
6	Within the book store towards the Northeast corner of the First Floor of Bentley House

Figure 5.1 Existing Site Plan showing Vibration Measurement Positions



The measurement positions are considered representative of vibration levels affecting the proposed student bedrooms.

Measurements were undertaken of vertical (z-axis) L_{max} 1/3 octave r.m.s. vibration acceleration levels between 1Hz and 1000Hz using a Dytran 3100D24 accelerometer (serial number 6644) connected to a 01dB Solo noise and vibration meter (serial number 60461) via a Dytran 6010A30 cable, in turn connected to a Dell laptop PC via a USB cable.

The accelerometer was calibrated by sensitivity prior to the vibration measurements.

6 SURVEY RESULTS & OBSERVATIONS

Measured 1/3 octave band r.m.s vibration acceleration levels at each position are shown in Figures B1 to B6 in Appendix B. The graphs show measured vibration levels measured during underground train pass-bys at each position.

Subjectively, tactile vibration due to underground train pass-bys was not clearer perceptible, or noted, at any of the measurement positions. However, re-radiated noise due to underground train pass-bys was audible at positions 1 to 4 and position 6, as background noise levels were generally low enough to make the train pass-bys audible. At position 5, noise levels from road traffic breaking in through the existing glazing masked re-radiated noise to the extent that it was inaudible.

7 PREDICTED VIBRATION AND RE-RADIATED NOISE

7.1 Assumptions

The level of vibration transmitted from the ground into a building structure, and hence the level of re-radiated noise, is dependent on a variety of factors. Based on correspondence with Watermans Structures Ltd (Project Structural Engineers), we understand that the completed building is likely to comprise the following structure:

	Front of building (overlooking Euston Road)	Rear of Building
Foundations	Retained existing foundations – understood to be shallow rafts	New piled foundations
Building Frame	Retained - Concrete substructure Retained - Steel superstructure	New - Concrete substructure New - Concrete superstructure
Bedroom Floor Build-up	To include resilient floating screed or resilient platform floor construction to meet Approved Document E Impact Sound Insulation requirements	

For the purposes of our re-radiated noise calculations, room dimensions are assumed to be at least 3m (L) x 3m (W) x 2.5m (H), and rooms are assumed to be carpeted with typical soft furnishings.

Our calculations are based upon the empirically researched floor amplification factors given in "*A Prediction for Rail Transportation Ground-borne Noise and Vibration*"[3] and "*Handbook for Urban Noise and Vibration Control*"[4].

7.2 Vibration

The measured vibration levels presented in Appendix B have been used to determine estimated Vibration Dose Values (e.V.D.V). Our calculation of e.V.D.Vs are based on the assumptions presented in Table 7.1 and the maximum vibration levels measured for train pass-by at each position. In addition, a value of 80 train movements on the District, Circle and Hammersmith & City underground Lines per hour and 60 train movements on Victoria underground Line per hour have been assumed as a worst-case based on London underground timetables.

Table 7.2 presents the predicted e.V.D.V.'s for daytime and night-time hours throughout the lower floors of the completed building, compared to Camden Council's typical standards.

Table 7.2 Predicted e.V.D.V.'s

Measurement Position	Floor	Location	Predicted e.V.D.V. ($m/s^{1.75}$)	
			Daytime (0700-2300)	Night (2300-0700)
1	Basement	Front	0.023	0.019
2		Rear	0.021	0.018
3	Ground Floor	Front	0.024	0.020
4		Rear	0.021	0.017
5	First Floor	Front	0.040	0.033
6		Rear	0.035	0.030

Camden Council Typical Standards	0.2 to 0.4	< 0.13

We note the estimated Vibration Dose Values, presented in Table 7.2 above, comfortably less than the maximum values specified by Camden Council's typical standards, presented in Section 4.1, at all measurement positions.

7.3 Re-radiated Noise

Predicted re-radiated L_{Amax} noise levels at each position are shown in Table 7.3 and compared to Camden Council's typical standards.

Table 7.2 Predicted Re-radiated L_{Amax} Noise Levels

Measurement Position	Floor	Location	Predicted Re-radiated L_{Amax} Noise Level (dB)
1	Basement	Front	35
2		Rear	34
3	Ground Floor	Front	30
4		Rear	32
5	First Floor	Front	35
6		Rear	33
Camden Council Typical Standard			≤ 35

It can be seen that the predicted re-radiated noise levels due to nearby train movements are equal to or less than Camden Council's typical L_{Amax} criterion of 35dB at all positions throughout the proposed development.

It should be noted that the predicted re-radiated noise levels presented in Table 7.2 are based on the worst-case (i.e. maximum) vibration levels measured throughout our survey.

7.4 Summary

The estimated Vibration Dose Values comfortably satisfy Camden Borough Council's typical standards and should therefore be considered acceptable.

In addition, worst-case (maximum) levels of re-radiated noise are predicted to be equal to or less than Camden Borough Council's typical standards.

APPENDIX A: NOISE AND VIBRATION TERMINOLOGY

VIBRATION

The vibratory motion of a surface can be characterised by:

(a) displacement (m),

(b) velocity (m/s), or

(c) acceleration (m/s^2).

The magnitude of the vibration can be quantified in several ways:

Peak to Peak

The total excursion of the oscillation about the zero datum.

Peak

This value gives the maximum excursion of the oscillation above or below the zero datum.

r.m.s.

This value gives the root mean square of the time history over a specific time interval (time constant).

dB

Vibration levels can be expressed in dB. A reference level of 10^{-6} m/s^2 r.m.s. is usually used for acceleration.

Vibration Dose Value, V.D.V. ($m/s^{1.75}$)

The V.D.V. assesses both the magnitude of vibration and its duration. It can be estimated from the frequency weighted r.m.s. value of the acceleration and its duration and is then referred to as the estimated Vibration Dose Value (e.V.D.V.).

Re-radiated Noise

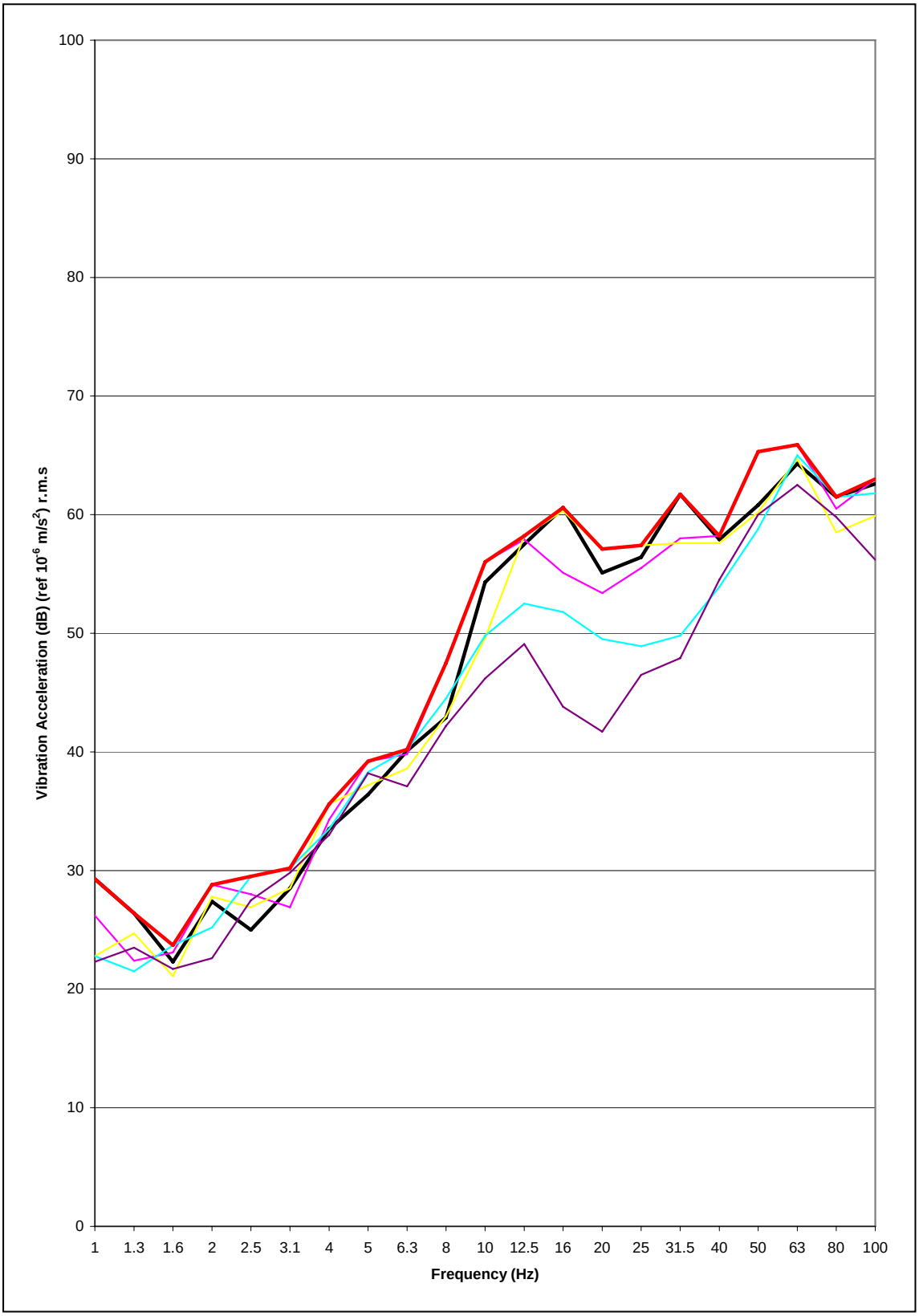
The level of noise, in dB, radiated by a surface excited by vibration, e.g. a floor or wall.

NOISE

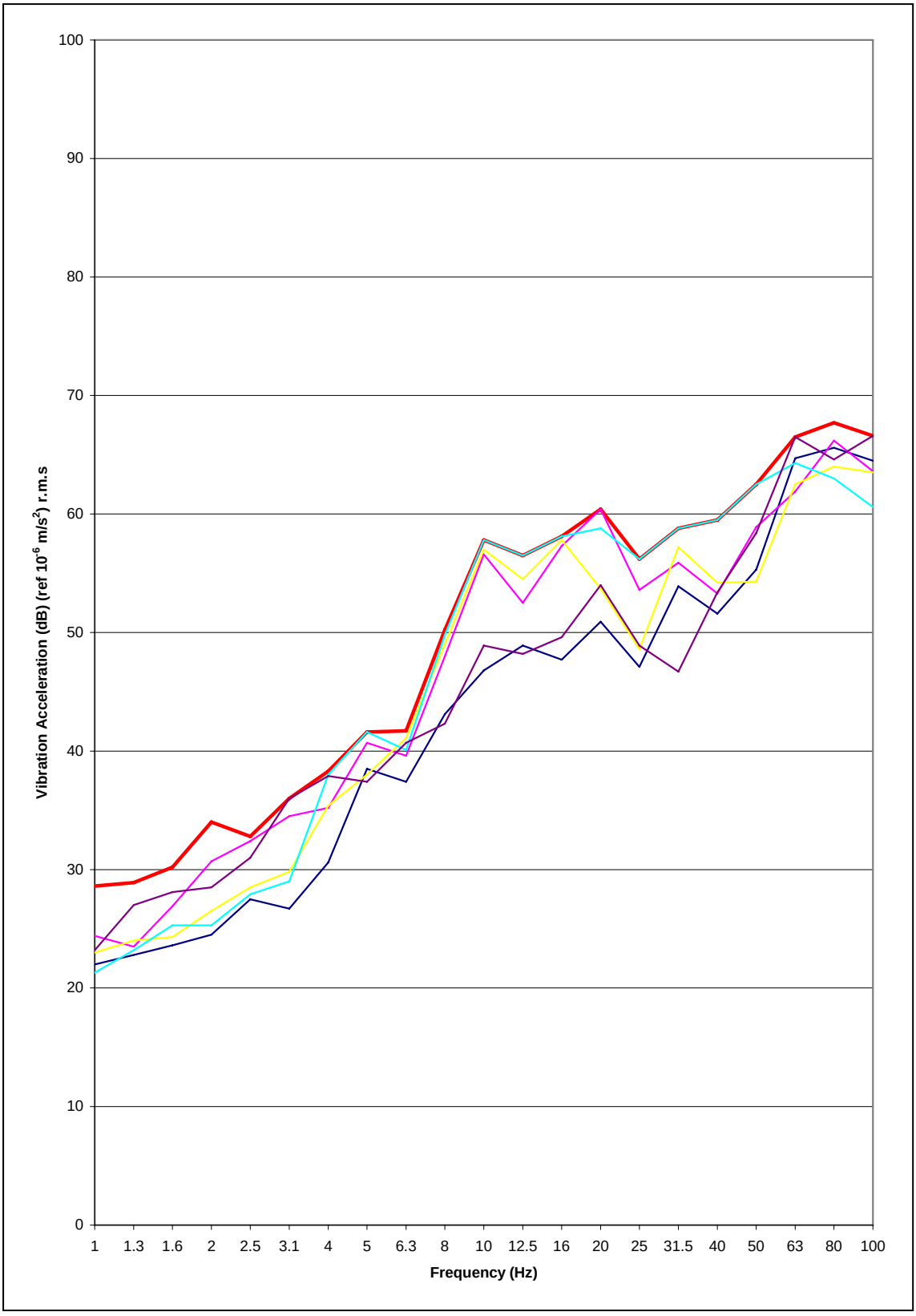
Parameter	Description
Decibel (dB)	A logarithmic scale representing the sound pressure or power level relative to the threshold of hearing ($20x10^{-6}$ Pascals).
Sound Pressure Level (L_p)	The sound pressure level is the sound pressure fluctuation caused by vibrating objects relative to the threshold of hearing.
A-weighting (L_A or dBA)	The sound level in dB with a filter applied to increase certain frequencies and decrease others to correspond with the average human response to sound.
L_{Amax}	The A-weighted maximum noise level measured.

APPENDIX B: VIBRATION MEASUREMENT RESULTS

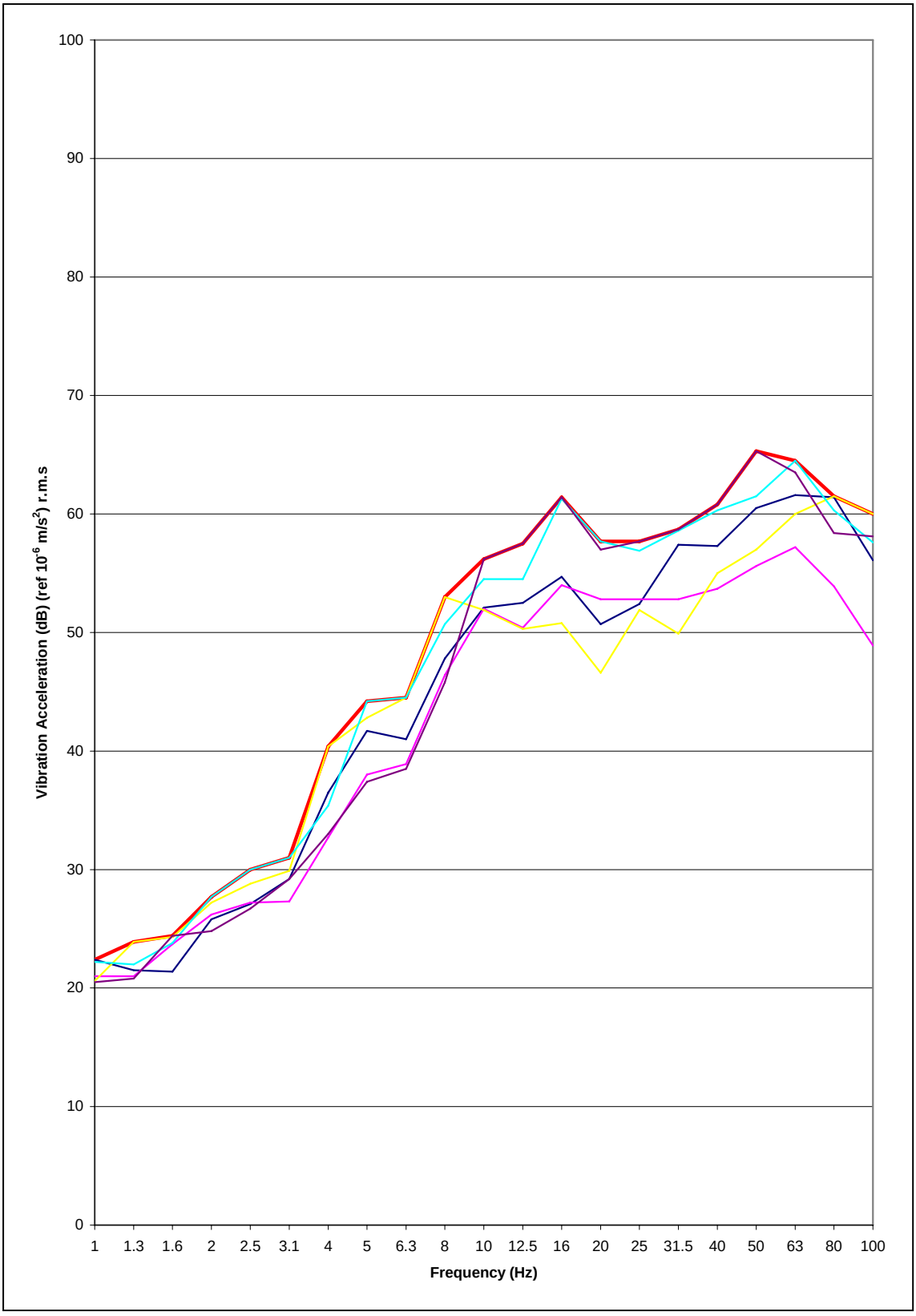
B1. Measured Vibration Acceleration at Position 1



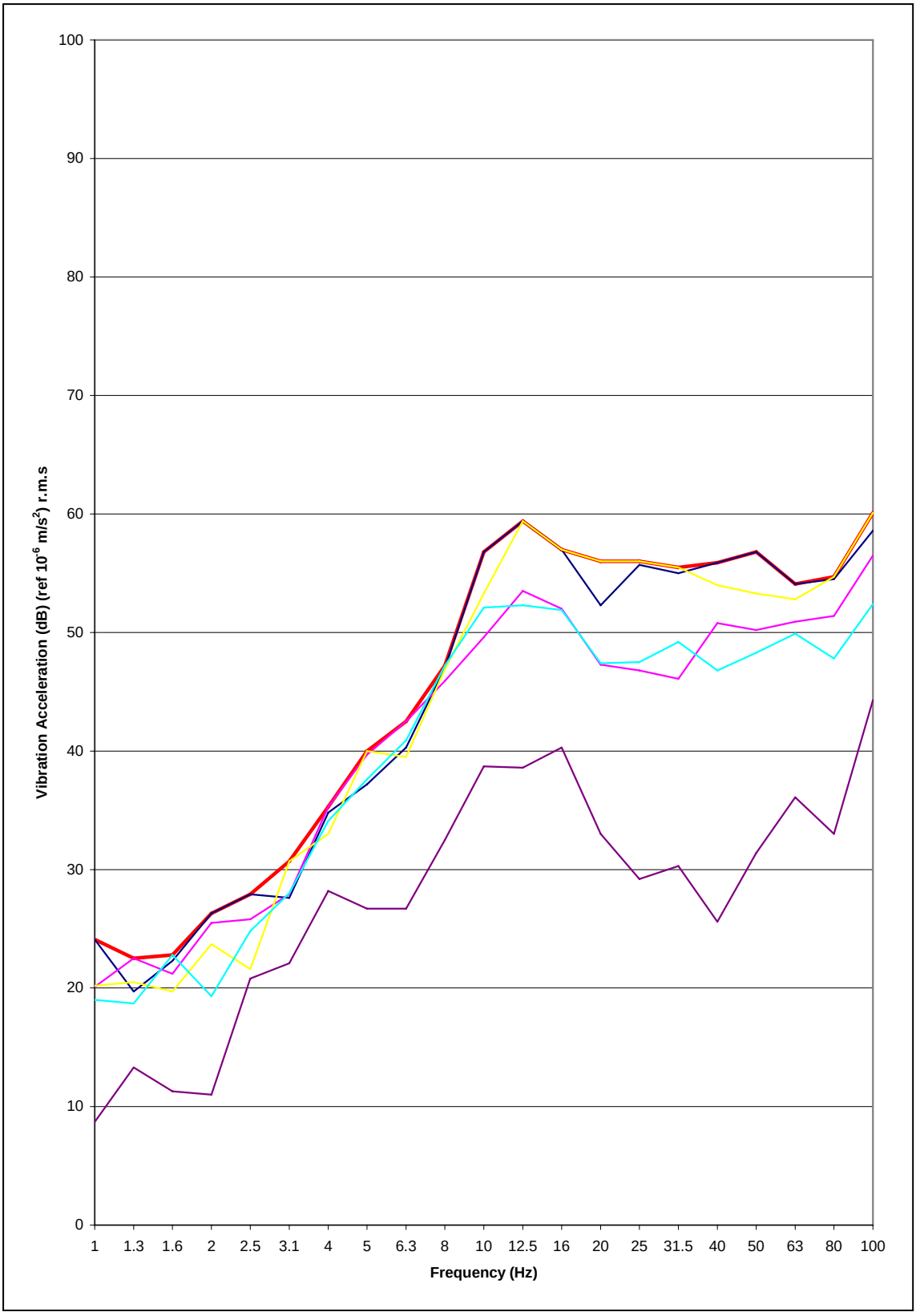
B2. Measured Vibration Acceleration at Position 2



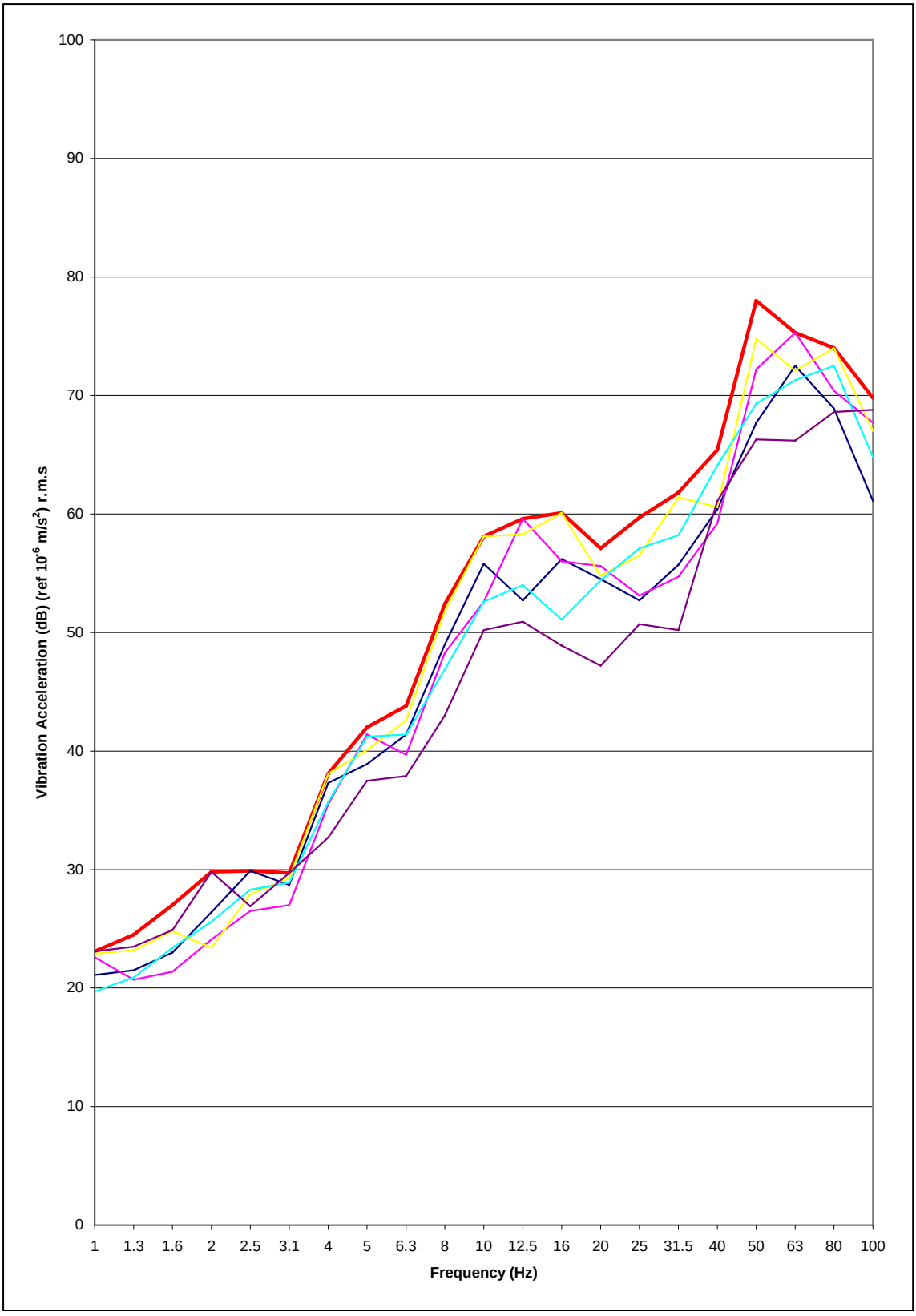
B3. Measured Vibration Acceleration at Position 3



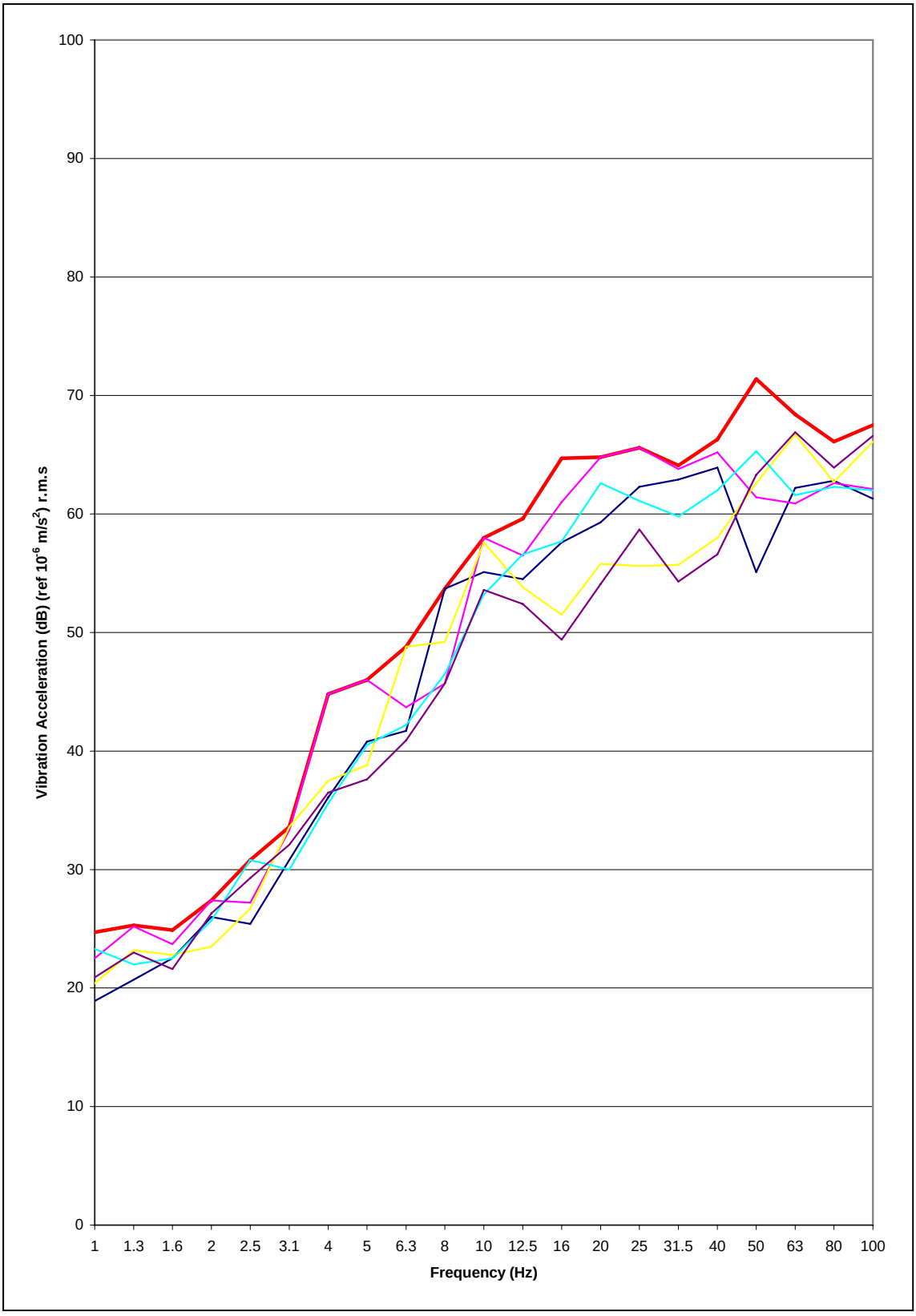
B4. Measured Vibration Acceleration at Position 4



B5. Measured Vibration Acceleration at Position 5



B6. Measured Vibration Acceleration at Position 6



DOCUMENT CONTROL & REFERENCES

Change History

Issue 0.1	22 April 2010	Document produced by Mark Brightwell and forwarded to Nicholas Jones for review.
Issue 0.2	23 April 2010	Document reviewed by Nicholas Jones and returned to Mark Brightwell for production and issue of final document.
Issue 0.3	26 April 2010	Draft document issued to design team for comment
Issue 0.4	10 May 2010	Draft document re-issued following comments from design team
Issue 1.0	21 May 2010	Final document issued

Changes Forecast

None.

Document References

1/2. London Borough of Camden *Replacement UDP*, Adopted June 2006

3. "*A Prediction Procedure for Rail Transportation Ground-borne Noise and Vibration*", James Turner Nelson and High Saurenman, Transportation Research Record 1143

4. "*Handbook of Urban Rail Noise and Vibration Control*" Saurenman, Nelson, Wilson, US Department of Commerce, National Technical Information Services, February 1982

5. World Health Organisation "*Guidelines for Community Noise"* 1999.