University College London Hospitals NHS
NHS Foundation Trust

Demolition of the existing buildings and redevelopment for a building of 6 storeys in height including ground and 3 storeys basement, for use a specialist head and neck facility (Class D1)

Former University College London (UCL) Student Union and Royal Ear Hospital, Huntley Street, Bloomsbury

Acoustic planning report

February 2015

SANDY BROWN

Consultants in Acoustics, Noise & Vibration

14275-R04-B

17 February 2015

UCLH Phase 5

Acoustic planning report

55 Charterhouse Street, London EC1M 6HA
Piccadilly House, 49 Piccadilly, Manchester M1 2AP
16 West Terrace, South Queensferry EH30 9LL

T: +44 (0)20 7549 3500
T: +44 (0)161 771 2020
T: +44 (0)131 331 2020

post@sandybrown.com
www.sandybrown.com

Sandy Brown Associates LLP
Registered in England & Wales No. OC 307504

Registered Office: 55 Charterhouse Street, London EC1M 6HA

Version	Date	Comments	Author	Reviewer
A	10 Feb 15		Helen Sheldon	Mark Howarth
B	17 Feb 15	Update following JLL comments	Helen Sheldon	Mark Howarth

Summary

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital and the former UCL students union, University College London Hospital (UCLH).

An environmental noise and vibration survey has been carried out at the site, full details of which are provided in reports 14275-R01-B and 14275-R02-A respectively. These reports are appended.

This report summarises the acoustic issues relevant to the planning application, and discusses how these are being addressed. These issues are:

- Noise egress from proposed new building services
- Noise egress from activities
- The impact of the building massing on the acoustic environment in the area.

Contents

1 Introduction 5
2 Site description 5
3 Plant noise egress assessment 7
4 Noise egress from activities 8
5 Vibration 8
6 Building massing 9
7 Conclusion 11
Appendix A 12
Environmental noise survey report, 14275-R01-B 12
Appendix B 33
Vibration survey report, 14275-R02-A 33

1 Introduction

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital, and the former University College London students union, UCLH.

This report summarises the acoustic issues relevant to the planning application, and discusses how these are being addressed. These issues are:

- Noise egress from proposed new building services
- Noise egress from activities
- The impact of the building massing on the acoustic environment in the area.

Reference is made to the environmental noise and vibration reports which are also appended for completeness.

2 Site description

2.1 The site and its surroundings

The site location in relation to its surroundings is shown in Figure 1. The site is highlighted in Red.

The main road passing the site is Huntley Street which runs parallel with Tottenham Court Road and Gower Street. Secondary roads include Torrington Place which links Huntley Street to Tottenham Court Road and Gower Street, and Capper Street to the northwest of the site.

The approximate proposed plant location is highlighted in green on Figure 1.

Figure 1 Site overview and surrounding area (courtesy of Google Earth Pro)

2.2 Adjacent premises

The nearest noise sensitive receptors are considered to be residential premises to the south (Gordon Mansions) and the east (opposite side of Huntley Street) of the site. These are highlighted in blue in Figure 1.

Other adjacent premises include commercial and retail properties to the north, and a gym to the west.

3 Plant noise egress assessment

3.1 Local Authority criteria

The London Borough of Camden (LBC) set out their planning noise policy as part of their document 'Camden Development Policies, 2010-2025', forming part of the local development framework. Policy DP28 states the noise levels which if exceeded, planning permission will not be granted.

Table E of the above document states that during the day, evening and night, noise at 1 m external to a sensitive facade should be at least 5 dB below the L_{A90} background noise level. It also states that noise which has a distinguishable discrete continuous note or distinct impulses should be at least 10 dB below the L_{A90} background noise level.

LBC does not currently have any formal literature dictating their requirements for noise limits from emergency plant items. However, from discussions with LBC it is understood that emergency plant items, when in 'emergency mode' only, should not exceed 10 dB above the minimum external background noise level experienced at the nearest noise sensitive receptor.

3.2 Plant noise limits

Based on the above criteria and the measurement results as detailed in report 14275-R01-B in Appendix A, the cumulative noise level resulting from the operation of all new plant at 1 m from the most affected windows of the nearest noise sensitive premises should not exceed the limits that are set out in Table 1.

Table 1 Plant noise limits at 1 m from the nearest noise sensitive premises

Time of day	Maximum sound pressure level at 1 m from noise sensitive premises (dB)	
	From general plant items	From emergency plant items
Daytime (07:00-23:00)	44	59
Night-time (23:00-07:00)	44	59

If the proposed plant noise contains attention catching features (such as tonal elements, whines, whistles, bangs, impulses etc), the plant should be designed to achieve a limit 5 dB below those set out above.

3.3 Preliminary plant noise assessment

A preliminary plant noise assessment has been carried out on the basis of the noise data received to date, and guidance has been provided on attenuation measures required to control noise emission. Full details of this have not been provided at this stage, as the building services design is still being developed, and the assessment is therefore subject to change.

However, any such changes in selection will be designed and attenuated such that the overall limits set out in Section 3.2 are complied with.

4 Noise egress from activities

4.1 Clinical activities

There are no activities proposed within the development which are expected to result in high noise levels, and the level of sound insulation required by the building envelope to control noise ingress to the development will ensure noise emission from normal clinical activities is well controlled, and as this element is not considered to be an issue.

4.2 Loading/deliveries

There is an enclosed loading bay proposed within the development. As the loading bay is internal, this serves to control noise emission to nearby noise sensitive premises from loading and unloading activities.

The entrance to the loading bay is located away from noise sensitive premises, which will minimise noise transmission to the surrounding residents.

5 Vibration

Vibration levels at the site are not expected to adversely affect the proposed development. Details are provided in the vibration survey report in Appendix B.

6 Building massing

It is understood that during public consultations, concerns have been raised over how the building massing may affect the noise climate in the area, with reference to the residential premises to the rear of Gordon Mansions. The concern was that the inclusion of the new building may exacerbate noise from existing and proposed new noise sources in the area, particularly via the gap between the proposed building and Shropshire Place. The sources that have been highlighted as a concern are as follows:

- Noise from pedestrians or activities in Shropshire Place/Queen's Yard to the rear
- Noise from existing plant items in the area
- Noise from the proposed plant installation associated with the proposed UCL Torrington Place development.

The proposed footprint of the building in relation to the existing surroundings is indicated in red in Figure 2. The proposed building is 5 storeys high, and follows broadly the same footprint for the height of the building.

The nearest noise sensitive premises (residential windows to the rear of Gordon Mansions) is indicated in Figure 2 by the letter 'R', and a proposed plant installation for a separate development (discussed in Section 0) is indicated by the letter 'P'.

Figure 2 Proposed building footprint (courtesy of Google Earth Pro)

6.1 Existing noise sources

Figure 3 indicates the site and the surroundings with 3-dimensional buildings. The inclusion of the new building will generally screen the existing residential premises from existing sources such as pedestrians on Queen's Yard and Shropshire Place, and if anything, noise from these sources will be slightly reduced.

However, there is a section of existing building which is one storey high, and the inclusion of the 5 storey high UCLH building may result in a canyon effect with the existing taller building to the other side. The potential 'canyon' is marked 'C' in Figure 3.

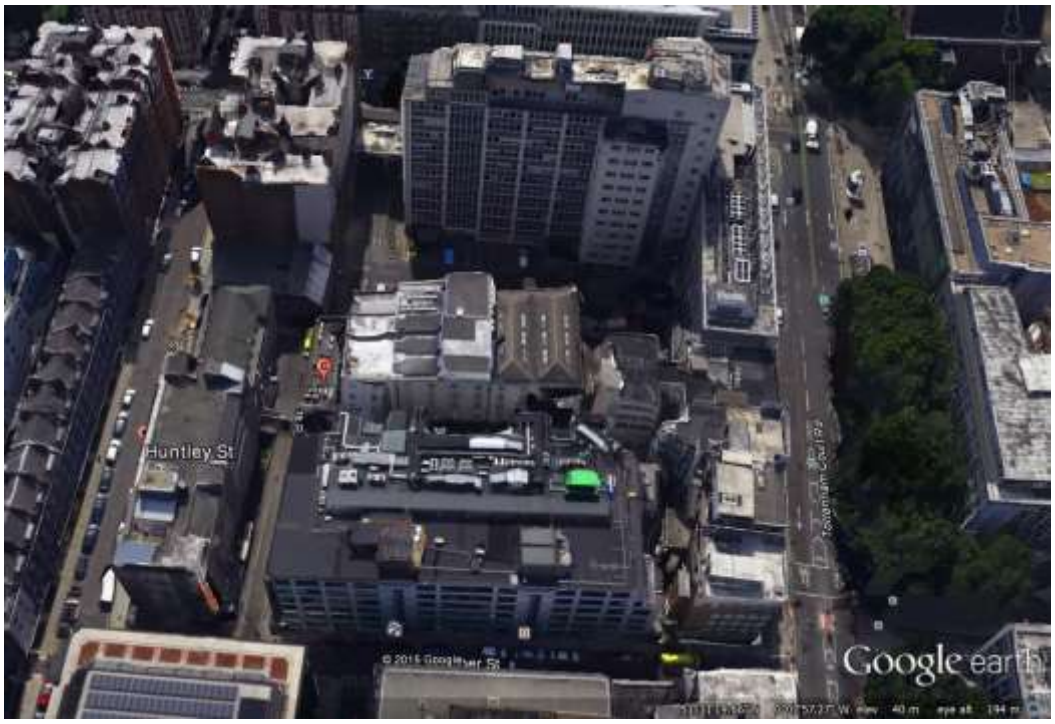

Figure 3 Site and the surrounding area with 3-dimensional buildings (courtesy of Google Earth Pro)

This would not be expected to have a significant effect on general sources in the area, but the aerial views in Figure 2 and Figure 3 indicate that there is existing plant located on the roof of the lower building. The inclusion of the proposed new building could slightly increase noise levels from this plant if it is operational.

It should be noted that the proposed new building facade on this elevation is angled such that reflections would be directed away from the residents.

Therefore, given the geometry and proximity of this plant to the residential premises, this increase would not be expected to be significant.

6.2 Torrington Place proposed plant installation

It is understood that a planning application was recently made by UCL for a data centre and associated plant on Torrington Place. The approximate location of the proposed plant is indicated by the letter 'P' in Figure 2.

The noise assessment submitted with the planning application for Torrington Place indicates that the plant has been selected and attenuated to achieve the acoustic requirements of LBC, assuming direct line of sight between the plant and the nearest noise sensitive premises at Gordon Mansions.

The relative positions of the UCLH Phase 5 development and the proposed Torrington Place plant installation and to the noise sensitive premises at Gordon Mansions are such that the former is not expected affect the noise assessment for the latter, as direct sound transmission between the plant and the residential premises will drive the assessment.

7 Conclusion

Noise egress from the proposed plant installation associated with the UCLH Phase 5 development will be designed such that it complies with the relevant noise limits as defined by LBC.

The proposed development is not expected to affect noise transmission from plant associated with the proposed UCL Torrington Place development, as direct sound transmission between the proposed plant installation and the residential premises will dominate.

The proposed development is not expected to result in increased noise transmission from existing general noise sources in the area.

The proposed new building could result in a 'canyon' effect, potentially increasing noise levels from existing plant items on a nearby low level roof. The angle of the proposed facade will direct reflections away from the residents, and bearing in mind the geometry and proximity to the nearby residents, any increase in noise from these items is not expected to be significant.

Appendix A

Environmental noise survey report, 14275-R01-B

SANDY BROWN

Consultants in Acoustics, Noise & Vibration

14275-R01-B

10 February 2015

UCLH Phase 5

Environmental noise survey report

55 Charterhouse Street, London EC1M 6HA
Piccadilly House, 49 Piccadilly, Manchester M1 2AP
16 West Terrace, South Queensferry EH30 9LL

T: +44 (0)20 7549 3500
T: +44 (0)161 771 2020
T: +44 (0)131 331 2020

post@sandybrown.com
www.sandybrown.com

Sandy Brown Associates LLP
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Version	Date	Comments	Author	Reviewer
A	29 Aug 14		Aaron Tomlinson	Helen Sheldon
B	10 Feb 15	Update following issue of latest design	Helen Sheldon	Mark Howarth

Summary

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital, University College London Hospital (UCLH).

An environmental noise survey has been carried out with a view to determining the existing background noise levels in the area and setting appropriate plant noise limits in line with the requirements of Camden Council.

The noise survey was performed between 13:45 on 18 July 2014 and 14:55 on 22 July 2014.

The lowest background noise levels measured during the survey were $L_{A90,5min}$ 49 dB during the daytime and $L_{A90,5min}$ 49 dB at night.

Based on the requirements of the London Borough of Camden and on the results of the noise survey, all plant must be designed such that the cumulative noise level at 1 m from the worst affected windows of the nearby noise sensitive premises does not exceed L_{Aeq} 44 dB during the daytime, and L_{Aeq} 44 dB during the night. Additionally, emergency plant must be designed such that the cumulative noise level at 1 m from the worst affected windows of the nearby noise sensitive premises does not exceed L_{Aeq} 59 dB during the daytime, and L_{Aeq} 59 dB during the night.

Contents

1 Introduction 5
2 Site description 6
3 Method 7
4 Measurement results 9
5 Noise egress assessment 13
6 Conclusion 14
Appendix A 15
Equipment calibration information 15
Appendix B 17
Results of unattended measurements at Location A 17
Appendix C 19
Results of unattended measurements at Location B 19

1 Introduction

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital, UCLH.

An environmental noise survey has been carried out at the site, the purpose of which was to establish the existing background noise levels in the vicinity of nearby noise sensitive premises. The background noise levels measured enable appropriate limits to be set regarding noise emission from proposed building services plant. These limits are to be set in accordance with the requirements of Camden Council.

This report presents the survey method, results of the environmental noise survey, and a discussion of acceptable limits for noise emission from building services plant.

2 Site description

2.1 The site and its surroundings

The site location in relation to its surroundings is shown in Figure 1. The site is highlighted in Red.

The main road passing the site is Huntley Street which runs parallel with Tottenham Court Road and Gower Street. Secondary roads include Torrington Place which links Huntley Street to Tottenham Court Road and Gower Street, and Capper Street to the northwest of the site.

Unattended noise logging locations are marked on Figure 1 as letters 'A' and 'B'.

Attended noise measurement locations are marked on Figure 1 as numbers 1 to 3.

Proposed plant location is highlighted in green on Figure 1.

Figure 1 Site overview and surrounding area courtesy of Google Earth

2.2 Adjacent premises

The nearest noise sensitive receptors are considered to be residential premises to the south and the east of the site. These are highlighted in blue in Figure 1.

Other adjacent premises include commercial and retail properties to the north, and a gym to the west.

3 Method

3.1 Unattended measurements

A 4 day unattended continuous noise logging survey was undertaken at the site to determine the existing background noise levels in the vicinity of nearby noise sensitive premises.

The unattended measurements were performed over 5 minute periods between 13:45 on 18 July 2014 and 14:55 on 22 July 2014.

The measurement positions used during the survey are indicated in Figure 1, denoted by the letters 'A' and 'B'. Photographs showing the measurement locations are provided Figure 2. These locations were chosen to be reasonably representative of the noise levels experienced by the nearest noise sensitive premises. At both locations the sound level meters were set up on the roof, with the microphone approximately 1.5m above the ground and at least 1m from any other reflective surface.

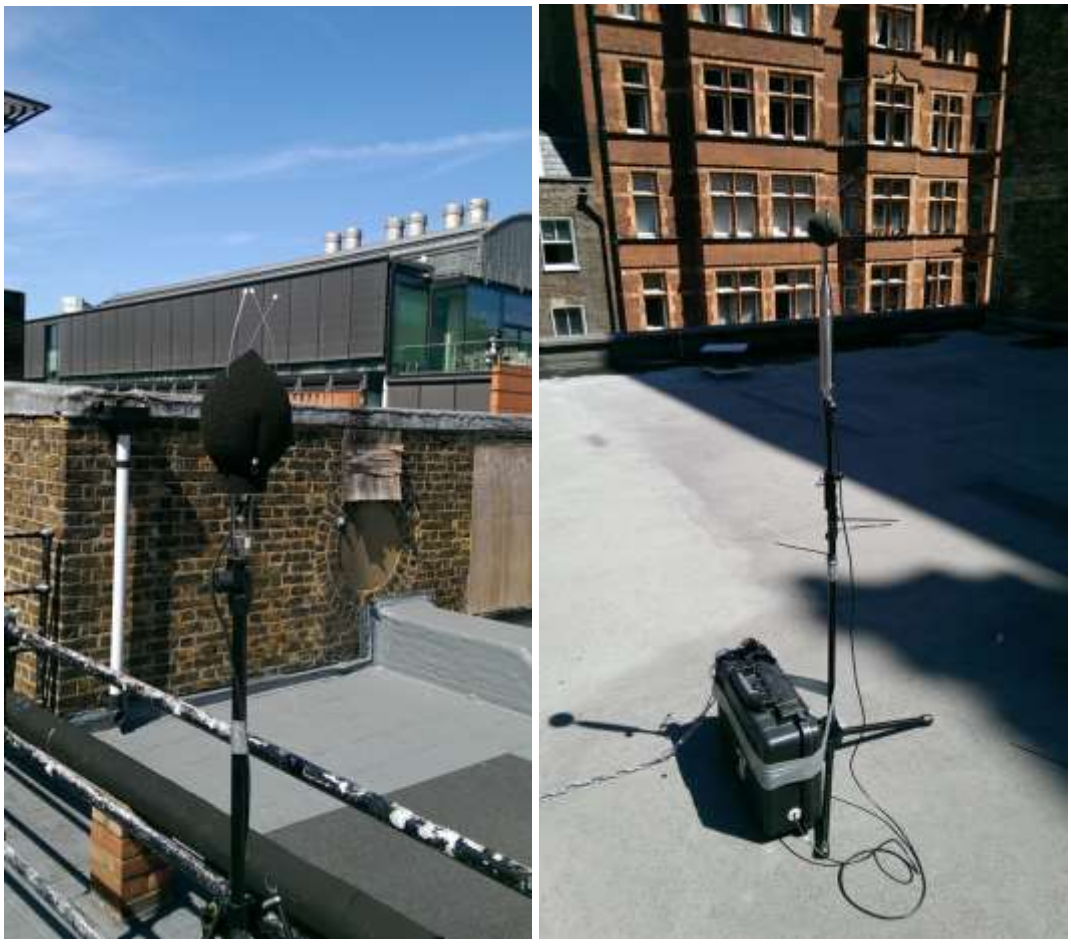


Figure 2 Location of loggers, at sites 'A' (left) and 'B' (right)

3.2 Attended measurements

Attended sample measurements were performed at a number of different locations around the site. These are indicated in Figure 1 as positions 1 to 3. The attended measurements were carried out on 18 July 2014, over 5 minute periods, with the purpose of determining the existing noise levels from road traffic, pedestrians and other significant noise sources in the area.

The locations of the measurements are indicated in Figure 1. In each case the microphone was mounted on a tripod approximately 1.5 m above the ground level and at least 1 m from any other reflective surface.

3.3 Equipment

Svantek 957 and Rion NL-52 sound level meters were used to undertake the unattended measurements. The attended measurements were carried out using a Brüel & Kjær 2250 sound level meter. The calibration data for the equipment used during the survey is provided in Appendix A to this report.

The sound level meters and microphones were calibrated at the beginning and end of the measurements using their respective sound level calibrators. No significant deviation in calibration occurred.

3.4 Noise indices

The equipment was set to record a continuous series of broadband sound pressure levels. Noise indices recorded included the following:

- $L_{Aeq,T}$ The A-weighted equivalent continuous sound pressure level over a period of time, T.
- $L_{Amax,T}$ The A-weighted maximum sound pressure level that occurred during a given period. Measured using the fast time weighting in accordance with the requirements of BS 8233 : 1999.
- $L_{A90,T}$ The A-weighted sound pressure level exceeded for 90% of the measurement period. Indicative of the background noise level.

The L_{A90} is considered most representative of the background noise level for the purposes of complying with any local authority requirements.

Sound pressure level measurements are normally taken with an A-weighting (denoted by a subscript 'A', eg L_{A90}) to approximate the frequency response of the human ear.

A more detailed explanation of these quantities can be found in BS7445: Part 1: 2003 *Description and measurement of environmental noise, Part 1. Guide to quantities and procedures.*

3.5 Weather conditions

During the attended measurements carried out on 18 July 2014, the weather was generally clear and dry and no rain occurred. Wind speeds varied between approximately 5 m/s and 10 m/s.

During the unattended noise measurements between 18 July 2014 and 22 July 2014, weather reports for the area indicated that temperatures varied between 16°C at night and 31°C during the day, and the wind speed was less than 5 m/s.

These weather conditions are considered suitable for obtaining representative measurements.

4 Measurement results

4.1 Observations

The dominant noise sources observed at the site during the survey consisted road traffic noise and plant noise.

Less significant noise sources included air traffic, pedestrians and birdsong.

4.2 Unattended measurement results

The results of the unattended noise measurements performed at the site are summarised in the following tables. Graphs showing the results of the unattended measurements are provided in Appendix B and Appendix C of this report for unattended noise logging locations ‘A’ and ‘B’, respectively.

4.2.1 Unattended measurement location 'A'

The day and night time ambient noise levels measured during the unattended survey at location 'A' are presented in Table 1.

Table 1 Ambient noise levels measured during the survey at measurement location 'A'

Date	Daytime (07:00 – 23:00) $L_{Aeq,16h}$ (dB)	Night (23:00 – 07:00) $L_{Aeq,8h}$ (dB)
18 July 2014	55*	54
19 July 2014	55	53
20 July 2014	54	53
21 July 2014	56	53
22 July 2014	56*	-
Average	55	53

* Measurement not made over full period due to monitoring start and end time; not included in the average

The minimum background noise levels measured during the unattended survey at measurement location 'A' are given in Table 2.

Table 2 Minimum background noise levels measured during the survey at measurement location 'A'

Date	Daytime (07:00 – 23:00) $L_{A90,5min}$ (dB)	Night (23:00 – 07:00) $L_{A90,5min}$ (dB)
18 July 2014	54*	52
19 July 2014	52	52
20 July 2014	52	52
21 July 2014	53	52
22 July 2014	53*	-

* Measurement not made over full period due to monitoring start and end time

The lowest background noise levels measured during the survey at measurement location 'A' were $L_{A90,5min}$ 52 dB during the daytime and $L_{A90,5min}$ 52 dB at night.

4.2.2 Unattended measurement location 'B'

The day and night time ambient noise levels measured during the unattended survey at location 'B' are presented in Table 1.

Table 3 Ambient noise levels measured during the survey at measurement location 'B'

Date	Daytime (07:00 – 23:00) $L_{Aeq,16h}$ (dB)	Night (23:00 – 07:00) $L_{Aeq,8h}$ (dB)
18 July 2014	55*	51
19 July 2014	52	51
20 July 2014	52	51
21 July 2014	55	51
22 July 2014	56*	-
Average	53	51

* Measurement not made over full period due to monitoring start and end time; not included in the average

The minimum background noise levels measured during the unattended survey at measurement location 'B' are given in Table 2.

Table 4 Minimum background noise levels measured during the survey at measurement location 'B'

Date	Daytime (07:00 – 23:00) $L_{A90,5min}$ (dB)	Night (23:00 – 07:00) $L_{A90,5min}$ (dB)
18 July 2014	51*	49
19 July 2014	49	49
20 July 2014	49	49
21 July 2014	50	49
22 July 2014	51*	-

* Measurement not made over full period due to monitoring start and end time

The lowest background noise levels measured during the survey at measurement location 'B' were $L_{A90,Xmin}$ 49 dB during the daytime and $L_{A90,Xmin}$ 49 dB at night.

4.3 Attended measurement results

Attended measurements were performed at a number of different locations around the site on 18 July 2014. The sound pressure levels recorded during these measurements are summarised in Table 5 in terms of the most notable parameters. The dominant noise sources noted during the measurements are also described in the following table. All the attended measurements were performed over 5 minute periods.

Table 5 Sound pressure levels from attended measurements

Position	Start Time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{Amax,5min}$	$L_{A90,5min}$	
1	16:45	59	75	55	Road traffic from Tottenham Court Road, pedestrians, plant, air traffic
	16:50	58	75	55	
	17:45	60	76	57	
	17:50	62	81	57	
2	17:00	56	73	51	Road traffic from Torrington Place, pedestrians, air traffic, birdsong
	17:05	56	71	51	
	18:00	57	76	53	
	18:05	57	70	53	
3	17:15	58	67	56	Plant noise, road traffic from Capper Street
	17:20	57	69	56	
	18:15	58	64	57	
	18:20	58	63	57	

5 Noise egress assessment

5.1 Local Authority criteria

Camden Council requires that the cumulative noise level from new plant items 1 m away from noise sensitive receptors is 5 dB below background level.

Camden Council do not currently have any formal literature dictating their requirements for noise limits from emergency plant items. However, from discussions with Camden Council it is understood that emergency plant items, when in 'emergency mode' only, should not exceed 10 dB above the minimum external background noise level experienced at the nearest noise sensitive receptor.

5.2 Plant noise limits

Based on the above criteria and the measurement results, the cumulative noise level resulting from the operation of all new plant at 1 m from the most affected windows of the nearest noise sensitive premises should not exceed 5 dB below the minimum external background noise level, and from emergency plant should not exceed 10 dB above the minimum external background noise level. These limits are set out in Table 6.

Table 6 Plant noise limits at 1 m from the nearest noise sensitive premises

Time of day	Maximum sound pressure level at 1 m from noise sensitive premises (dB)	
	From general plant items	From emergency plant items
Daytime (07:00-23:00)	44	59
Night-time (23:00-07:00)	44	59

If the proposed plant noise contains attention catching features (such as tonal elements, whines, whistles, bangs etc), the plant should be designed to achieve a limit 5 dB below those set out above.

5.3 Assessment

A number of new plant items are proposed to be located on the roof and basement of the proposed development. These include new chillers, air handling plant and a life safety generator. Full details of the proposed plant installation are still being developed, and will be assessed in due course to ensure compliance with the relevant noise limits.

Initial assessments of early plant selections indicate that the proposed installations are commensurate with achieving the limits. However, the assessment will be developed as the building services design progresses.

The required attenuation measures will depend on the type and location of the plant items, but typical measures include in-duct attenuation, acoustic screens or acoustic louvres.

6 Conclusion

A noise survey has been carried out to determine the existing background noise levels in the vicinity of the site and surrounding noise sensitive premises. The minimum measured background noise levels were $L_{A90,5min}$ 49 dB during the day, and $L_{A90,5min}$ 49 dB during the night.

Based on the requirements of the London Borough of Camden and on the results of the noise survey, all plant must be designed such that the cumulative noise level at 1 m from the worst affected windows of the nearby noise sensitive premises does not exceed L_{Aeq} 44 dB during the daytime, and L_{Aeq} 44 dB during the night. Additionally, emergency plant must be designed such that the cumulative noise level at 1 m from the worst affected windows of the nearby noise sensitive premises does not exceed L_{Aeq} 59 dB during the daytime, and L_{Aeq} 59 dB during the night.

These limits are cumulative, and apply with all plant operating under normal conditions. If plant items contain tonal or attention catching features, the limits will be 5 dB more stringent than those set out above.

At this stage, no detailed information is available in relation to the proposed installation of building services plant. This will need to be assessed in detail as the design progresses and all plant items will be designed to achieve the plant noise limits set out above.

The required attenuation measures will depend on the type and location of the plant items, but typical measures include in-duct attenuation, acoustic screens or acoustic louvres.

Appendix A

Equipment calibration information

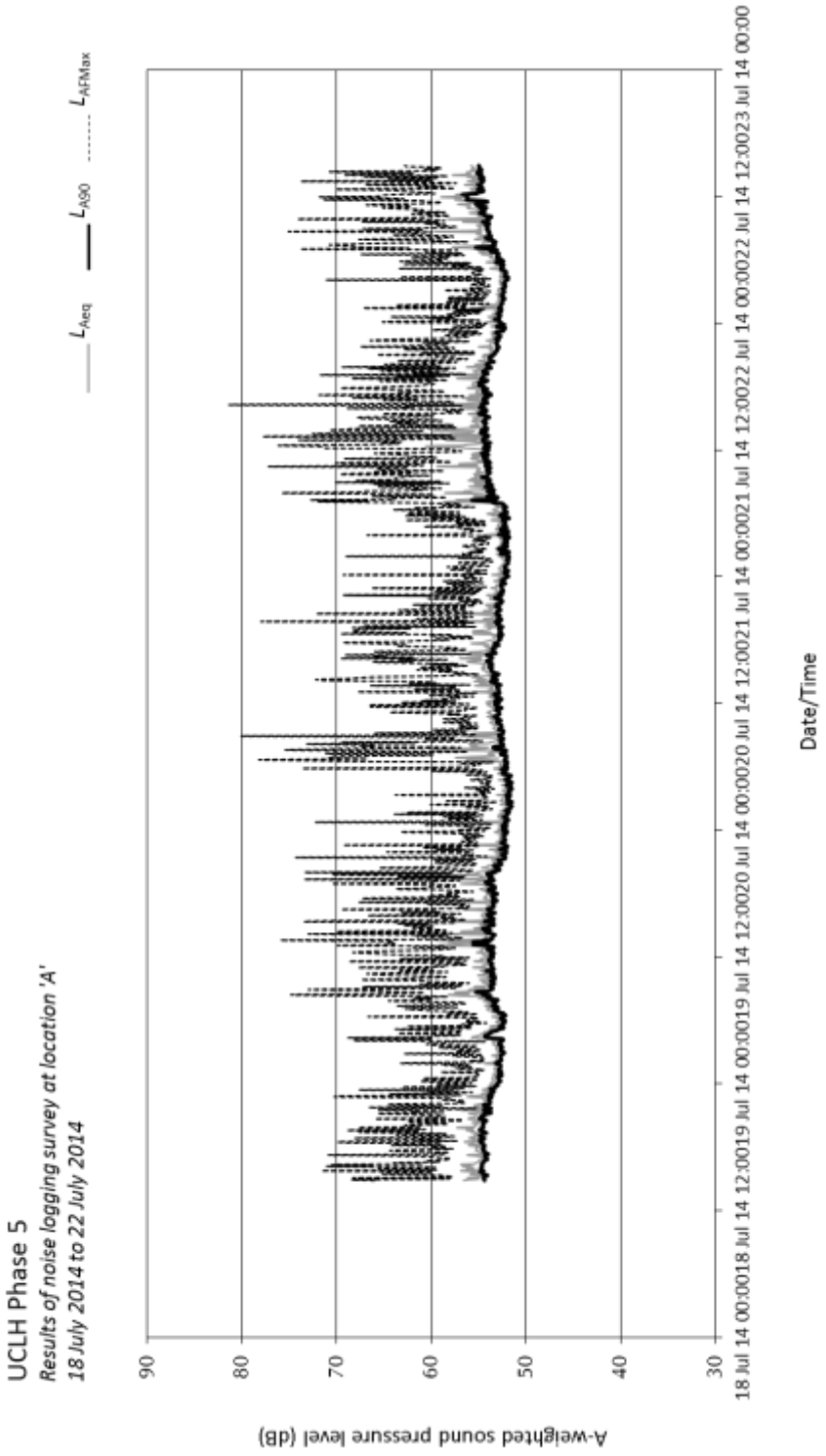
Table A1 Equipment calibration data

Equipment description	Type/serial number	Manufacturer	Calibration expiry	Calibration certification number
2250				
Sound level meter	2550/2693829	Bruel & Kjaer	30 Jan 16	07524/07525
Microphone	4189/2689268	Bruel & Kjaer	30 Jan 16	07524/07525
Pre Amp	ZC0032/12061	Bruel & Kjaer	30 Jan 16	07524/07525
Calibrator	4231/2558390	Bruel & Kjaer	30 Jan 16	07518
Svantek 957				
Sound level meter	SVAN957/12327	Svantek	23 Oct 15	1310490
Microphone	ACO7052H/43273	Svantek	23 Oct 15	1310490
Pre Amp	SV12L/13569	Svantek	23 Oct 15	1310490
Calibrator	SV30A/7451	Svantek	23 Oct 15	1310484
Rion NL-52				
Sound level meter	NL-52/00320633	Rion	16 Apr 16	1404200
Microphone	UC-59/03382	Rion	16 Apr 16	1404200
Pre Amp	NH-25/10641	Rion	16 Apr 16	1404200
Calibrator	N7-74/34125430	Rion	16 Apr 16	1404194

Calibration of the sound level meters used for the tests is traceable to national standards. The calibration certificates for the sound level meters used in this survey are available upon request.

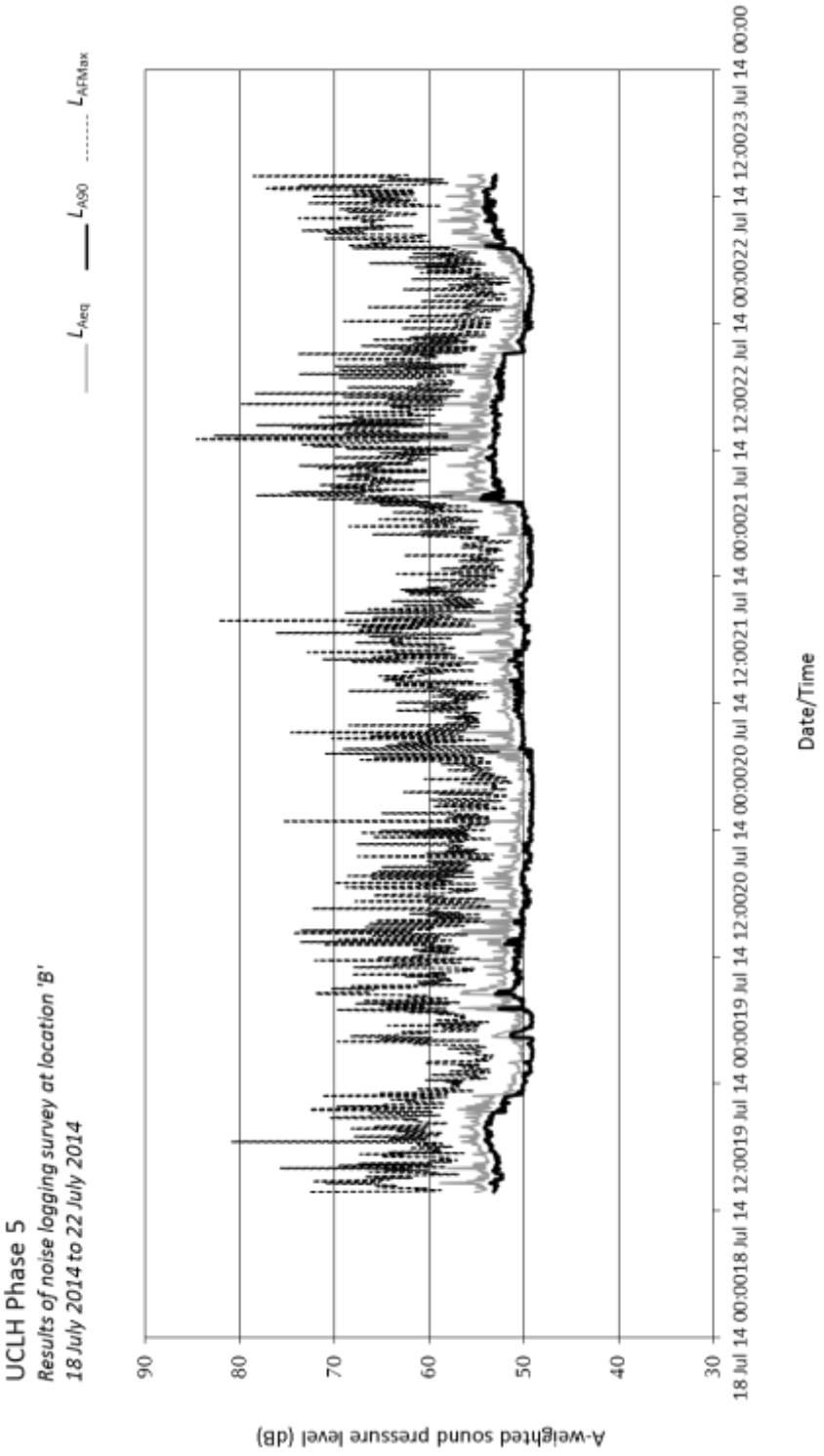
Appendix B

Results of unattended measurements at Location A


UCLH Phase 5
Results of noise logging survey at location 'A'
18 July 2014 to 22 July 2014
L_{Aeq}
L_{A90}
L_{AFMax}
A-weighted sound pressure level (dB)
90
80
70
60
50
40
30
18 Jul 14 00:0018 Jul 14 12:0019 Jul 14 00:0019 Jul 14 12:0020 Jul 14 00:0020 Jul 14 12:0021 Jul 14 00:0021 Jul 14 12:0022 Jul 14 00:0022 Jul 14 12:0023 Jul 14 00:00
Date/Time

Appendix C

Results of unattended measurements at Location B


UCLH Phase 5
Results of noise logging survey at location 'B'
18 July 2014 to 22 July 2014
L_{Aeq}
L_{A90}
L_{AFMax}
A-weighted sound pressure level (dB)
90
80
70
60
50
40
30
18 Jul 14 00:00
18 Jul 14 12:00
19 Jul 14 00:00
19 Jul 14 12:00
20 Jul 14 00:00
20 Jul 14 12:00
21 Jul 14 00:00
21 Jul 14 12:00
22 Jul 14 00:00
22 Jul 14 12:00
23 Jul 14 00:00
Date/Time

Appendix B

Vibration survey report, 14275-R02-A

SANDY BROWN

Consultants in Acoustics, Noise & Vibration

14275-R02-A

15 September 2014

UCLH Phase 5

Vibration survey report

55 Charterhouse Street, London EC1M 6HA
Piccadilly House, 49 Piccadilly, Manchester M1 2AP
16 West Terrace, South Queensferry EH30 9LL

T: +44 (0)20 7549 3500
T: +44 (0)161 771 2020
T: +44 (0)131 331 2020

post@sandybrown.com
www.sandybrown.com

Sandy Brown Associates LLP
Registered in England & Wales No. OC 307504

Registered Office: 55 Charterhouse Street, London EC1M 6HA

Version	Date	Comments	Author	Reviewer
A	15 Sep 14		Aaron Tomlinson	Helen Sheldon

Summary

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital, University College London Hospital (UCLH).

A vibration survey has been carried out at the site to evaluate the effects of ground-borne vibration induced by train movements along nearby London Underground Lines.

The vibration survey included attended vibration measurements taken on the concrete slab at basement level.

The results of the vibration surveys have been used to predict re-radiated noise and tactile vibration, which have been assessed against criteria proposed herein.

The predicted levels of re-radiated noise and tactile vibration indicate that vibration mitigation measures are not likely to be required.

Contents

1 Introduction 5
2 Site description 6
3 Assessment criteria 10
4 Measurement results 12
5 Vibration assessment 12
6 Conclusion 14
Appendix A 15
Equipment calibration information 15
Appendix C 17
VDV measurement results 17
Appendix D 19
RMS acceleration measurement results 19

1 Introduction

Sandy Brown Associates LLP (SBA) has been commissioned to provide acoustic advice in relation to the proposed development at the Royal Ear Hospital, UCLH.

The site is located to the east of the London Underground (LU) Northern Line between Goodge Street and Warren Street, and south of the LU Hammersmith and City, Circle, and Metropolitan lines between Great Portland Street and Euston Square.

An attended vibration survey has been undertaken at the existing site at 45 Huntley Street to evaluate the levels of train-induced ground borne vibration ingress into the building.

The survey includes a series of attended vibration measurements of individual train passes at basement level.

The results of the vibration survey were used to assess the degree to which the site is affected by tactile vibration with reference to '*BS 6472:2008 Evaluation of Human Exposure to Vibration in Buildings – Part 1: Vibration from sources other than blasting*'.

This report presents the vibration survey methods and results, along with an assessment of tactile vibration and re-radiated noise levels within the proposed buildings.

2 Site description

2.1 The site and its surroundings

The site location in relation to its surroundings is shown in Figure 1 and is highlighted in Red in the centre of the image. The LU Northern line is shown in Black with the closest parts to the west of the site, and the LU Hammersmith and city, Circle and Metropolitan lines are shown in pink, yellow and purple, respectively to the north of the site.

Figure 1 Site location relative to its surroundings and LU Northern line (Black), and Hammersmith and City, Circle and Metropolitan lines (Pink, Yellow and Purple, respectively)

2.2 Vibration measurement locations

The approximate locations at which vibration measurements were undertaken are shown in Figure 2 as positions 'V1' to 'V4'. Vibration measurements were undertaken within the basement of the building highlighted in red in Figure 2.

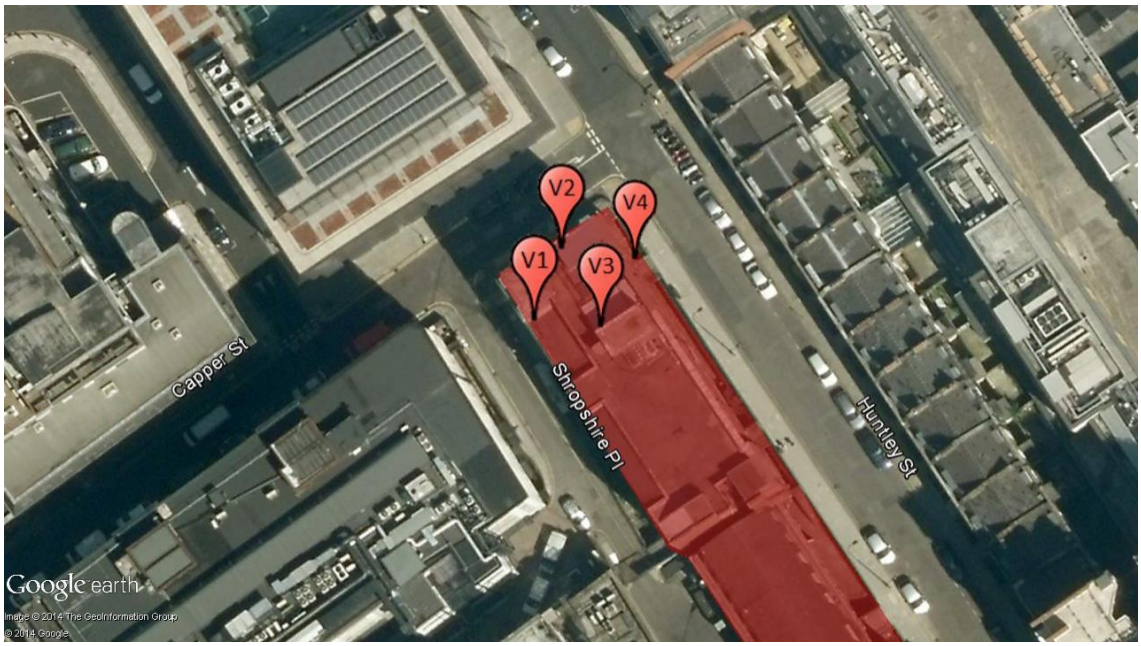


Figure 2 Approximate vibration measurement locations in basement of existing site overlaid onto site overview

2.3 Vibration survey method and equipment

Vibration measurements were performed at four locations within the existing building at basement level.

These locations were selected in order to facilitate a good understanding of vibration ingress to different parts of the site and to establish how vibration levels differ throughout the basement of existing building. Some images from the vibration survey are included within Figure 3.

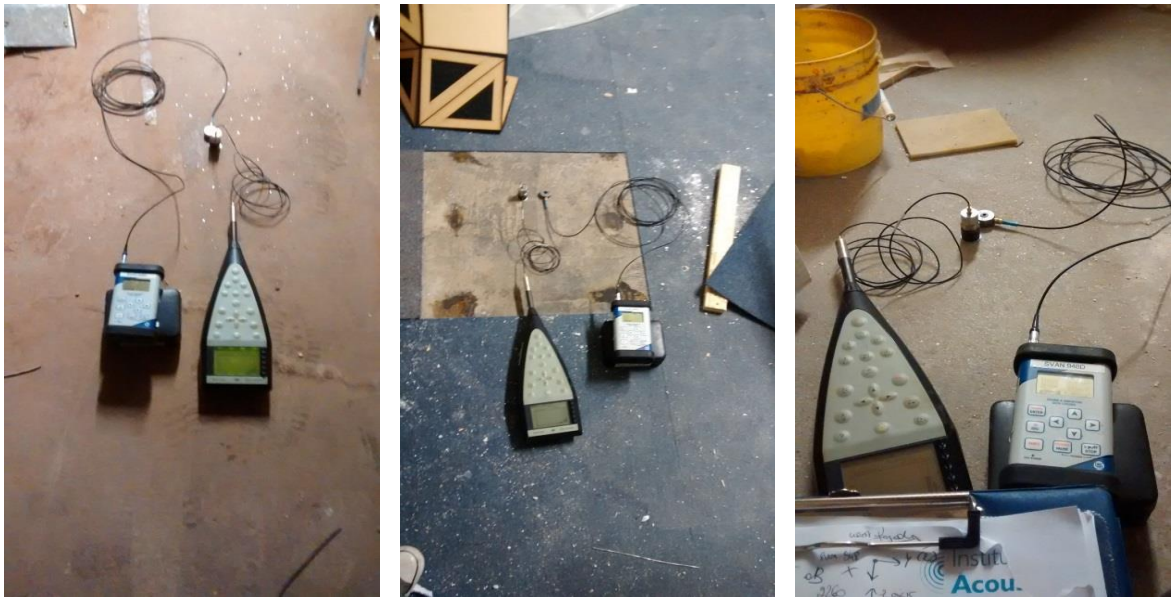


Figure 3 Photographs of vibration survey

RMS (Root Mean Squared) acceleration and event based Vibration Dose Values (VDVs) were measured at each location. VDVs can be used to assess the levels of tactile ('*feelable*') vibration within the proposed buildings and RMS acceleration can be used as part of an assessment of re-radiated noise levels within the proposed buildings.

The VDV measurements were carried out using a Svantek 948 vibration level meter. The 1/3 octave band RMS acceleration measurements were undertaken using a Bruel & Kjaer 2260 vibration level meter.

Calibration details of the equipment used during the vibration surveys are provided in Appendix A of this report.

The vibration level meters and the respective measurement chains were calibrated at the beginning and end of the measurements using their respective sound level calibrators. No significant calibration deviation occurred.

Attended vibration measurements were undertaken on 22 July 2014.

At each location the accelerometers were mounted upon a concrete slab, away from the walls.

The vibration measurements were conducted in three axes as follows:

- X axis - Horizontal vibration approximately perpendicular to the railway tracks
- Y axis - Horizontal vibration approximately parallel to the railway tracks
- Z axis - Vertical vibration.

The RMS acceleration measurements were performed in the vertical axis.

2.4 Noise and vibration indices

2.4.1 Noise indices

The following noise indices are referenced within this report:

- $L_{ASmax,T}$ The A-weighted maximum sound pressure level that occurred during a given period measured with the slow time weighting

Sound pressure level measurements are normally taken with an A-weighting (denoted by a subscript 'A', eg L_{ASmax} to approximate the frequency response of the human ear.

A more detailed explanation of these quantities can be found in BS7445: Part 1: 2003 *Description and measurement of environmental noise, Part 1. Guide to quantities and procedures.*

2.4.2 Vibration indices

For each measurement period a number of parameters were recorded. The most relevant of these are described below:

- The vibration dose value (VDV) in each of three axes with the appropriate frequency weightings (as defined in BS 6472)
- The maximum RMS acceleration levels in the vertical axis in one-third-octave bands, measured using the 'slow response' exponential time weighting.

3 Assessment criteria

3.1 Tactile vibration criteria

Tactile vibration is that which is perceived as mechanical motion. BS 6472 provides procedures for assessing the potential human response to vibration.

Vibration is assessed in terms of the equivalent Vibration Dose Value (VDV). This relates the level and duration of vibration.

BS 6472 includes guidance for the assessment of tactile vibration for residential and office buildings and these are presented in Table 1. It is recommended that these criteria be adopted for the assessment of tactile vibration within the proposed buildings.

Table 1 BS 6472 tactile vibration assessment criteria for residential and office buildings

Vibration dose values ($m/s^{1.75}$) above which might result in varying degrees of adverse comment

Place	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential building 8 hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Office building 16 hour day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2

It is important to note that people exhibit wide variations of vibration tolerance. Specific values are dependent upon social and cultural factors, psychological attitudes and expected degree of intrusion.

3.2 Re-radiated noise criteria

3.2.1 Residential building

There is currently no international or British Standard which provides guidance on assessing the impact of ground-borne noise from railways on the occupants of a hospital building. The Association of Noise Consultants (ANC) guidelines '*Measurement and assessment of ground-borne noise and vibration*', 2nd edition published in 2012, is generally used as the basis of assessments such as this.

This document also provides discussion on the relevant research that has been carried out, along with a summary of typically adopted criteria.

The most relevant items are set out below:

- The American Public Transit Association (APTA) guidelines recommend criteria of between 30 and 40 dB(A) depending on the density and type of residential properties. They do not define where within a building these apply, or the time response that should be used
- The Federal Transit Administration (FTA) of the US Department of Transportation, recommends limits for maximum pass-by levels of 35 dB(A) for frequent events (more than 70 events per day) and 43 dB(A) for infrequent events.
- London Underground Limited has studied the relationship between ground-borne noise levels and complaint thresholds. This was used to define a complaint threshold of 40 dB L_{Amax}.
- The ANC guidelines also note that Local Authority guidelines for ground-borne noise were published in London and the South East, and state a limit of 35 dB L_{Amax}.

In all of the above examples, the time constant is not defined, with the exception of the Local Authority guidelines in London and the South East, which is defined as having a fast time weighting.

It should be noted that most of this research relates to residential accommodation, and is aimed at providing good sleeping / resting conditions.

The level of structure-borne noise from underground trains within the building relates to the perception of quality. Audibility of such noise must take into account the likely level of underlying continuous background noise from sources such as mechanical ventilation, ie the lower this is the more pronounced will noise be from other events such as underground trains.

However, for the time being and on the basis of the criteria discussed above, a re-radiated noise limit of L_{ASmax} 35 dB is considered suitable for the proposed development.

4 Measurement results

4.1 Observations

Ground borne noise levels from the LU lines within the basement were audible at each location within the basement during the vibration survey.

4.2 Vibration measurement results

4.2.1 Tactile vibration measurements

The measured VDVs are tabulated within Appendix C. It can be seen that the highest tactile vibration levels were generally in the vertical (Z) axis at each position.

4.2.2 RMS acceleration measurements

RMS acceleration values were measured at each location. The results are presented as a series of graphs within Appendix D.

It can be seen that generally, the vibration levels are dominated by 50-80 Hz bands and 160-250 Hz bands. These levels coincide with the contribution from LU train passes.

The results of the RMS acceleration measurements have been used to predict re-radiated noise levels within the proposed buildings (refer to Section 5.2).

5 Vibration assessment

5.1 Tactile vibration assessment

An analysis of the timetabled LU trains suggests that there are approximately 1600 passes during the daytime (07:00 – 23:00 hours) and 850 passbys during the night-time (23:00 – 07:00 hours).

BS 6472 states that the assessment should be based on the axis along which the highest Vibration Dose Values (VDV) is measured. Typically, the highest VDVs were measured within the vertical (Z) axis.

Based on the maximum vibration values detailed within Appendix C and the timetabled train passes, the calculated event based equivalent VDV over a 16 hour day and an 8 hour night are summarised in Table 2.

Table 2 Calculated daytime and night-time VDVs

Measurement position	VDV $_{16hr\ (daytime)}$	VDV $_{8hr\ (night\text{-}time)}$
V1	0.01-0.02	0.00-0.01
V2	0.00-0.01	0.00-0.01
V3	0.01-0.02	0.01-0.02
V4	0.03-0.06	0.04-0.05

It is important to note that the calculated VDVs displayed in Table 2 are based on the measured VDVs at the measurement locations and no amplification factors and losses to other levels within the proposed development have been applied within this calculation.

Measurement location V1 is considered representative of the west side of the building, with V2 considered representative of the north side of the building and V4 considered representative of the east side of the building.

When compared against the criteria detailed in Table 1, tactile vibration within the building is predicted to fall below the '*Low probability of adverse comment*' range. As such, tactile vibration is not considered to be an issue.

5.2 Predicted re-radiated noise levels

The measured RMS acceleration levels presented within Appendix C have been used to predict re-radiated noise levels within the proposed buildings, using the empirical methodology described in '*Guidelines for the Measurement & Assessment of Groundborne Noise and Vibration (2nd Edition)*' published by the Association of Noise Consultants in 2012.

The predicted re-radiated noise levels are detailed in Table 3.

Table 3 Predicted re-radiated noise levels

Measurement position	Typical predicted L_{ASmax} , dB	Highest predicted L_{ASmax} event, dB
V1	16-19	19
V2	23-26	27
V3	24-32	32
V4	24-26	27

It is important to note that the predicted re-radiated noise levels displayed in Table 3 are based on the measured RMS acceleration levels at the measurement locations and no amplification factors and losses to other levels within the proposed development have been applied within this calculation.

The predicted re-radiated noise levels at measurement locations V1 to V4 are within the criteria detailed in section 3.2. As such, re-radiated noise is not considered to be an issue.

Measurement location V3 was perceived to be subjectively the location at which re-radiated noise was highest due to train passes. Even so, the highest predicted re-radiated noise levels are comfortably within the criteria laid out in section 3.2.

5.3 Vibration sensitive equipment

Discussions have indicated that there are no items of vibration sensitive equipment currently proposed within the development. It has therefore been assumed that no specific vibration isolation measured will be required, Should any such items be introduced to the scheme, it is considered that local isolation measures are likely to be sufficient given the relatively low levels of vibration at the site. However, this would be dependent on the proposed equipment and would need to be reviewed.

6 Conclusion

SBA has undertaken a vibration survey within the existing building at the proposed development site for UCLH phase 5.

The measurements have been used to assess levels of tactile vibration and re-radiated noise within the proposed development at the site. These have been compared against criteria proposed herein in order to establish whether vibration mitigation is likely to be required.

The predicted levels of both re-radiated noise and tactile vibration indicate that vibration mitigation measures are not likely to be required.

Vibration at the proposed site of development is not considered to be an issue.

Appendix A

Equipment calibration information

Table A1 Equipment calibration data

Equipment description	Type/serial number	Manufacturer	Calibration expiry	Calibration certification number
		2260		
Sound level meter	2260/2553982	Bruel & Kjaer	24 July 16	07844/07845
Pre Amp	ZC0026/4585	Bruel & Kjaer	24 July 16	07844/07845
		948		
Vibration meter	SVAN948/11517	Svantek	28 Jul 16	1407381
Accelerometer	3233A/221	Dytran	28 Jul 16	1408382
Calibrator	SV30A/10576	Svantek		

The calibration certificates for the sound level meters stated above are available upon request.

Calibration of the sound level meters used for the measurements is traceable to national standards. The sound level meters and the respective measurement chains were calibrated at the beginning and end of the measurements using their respective sound level calibrators.

Appendix C

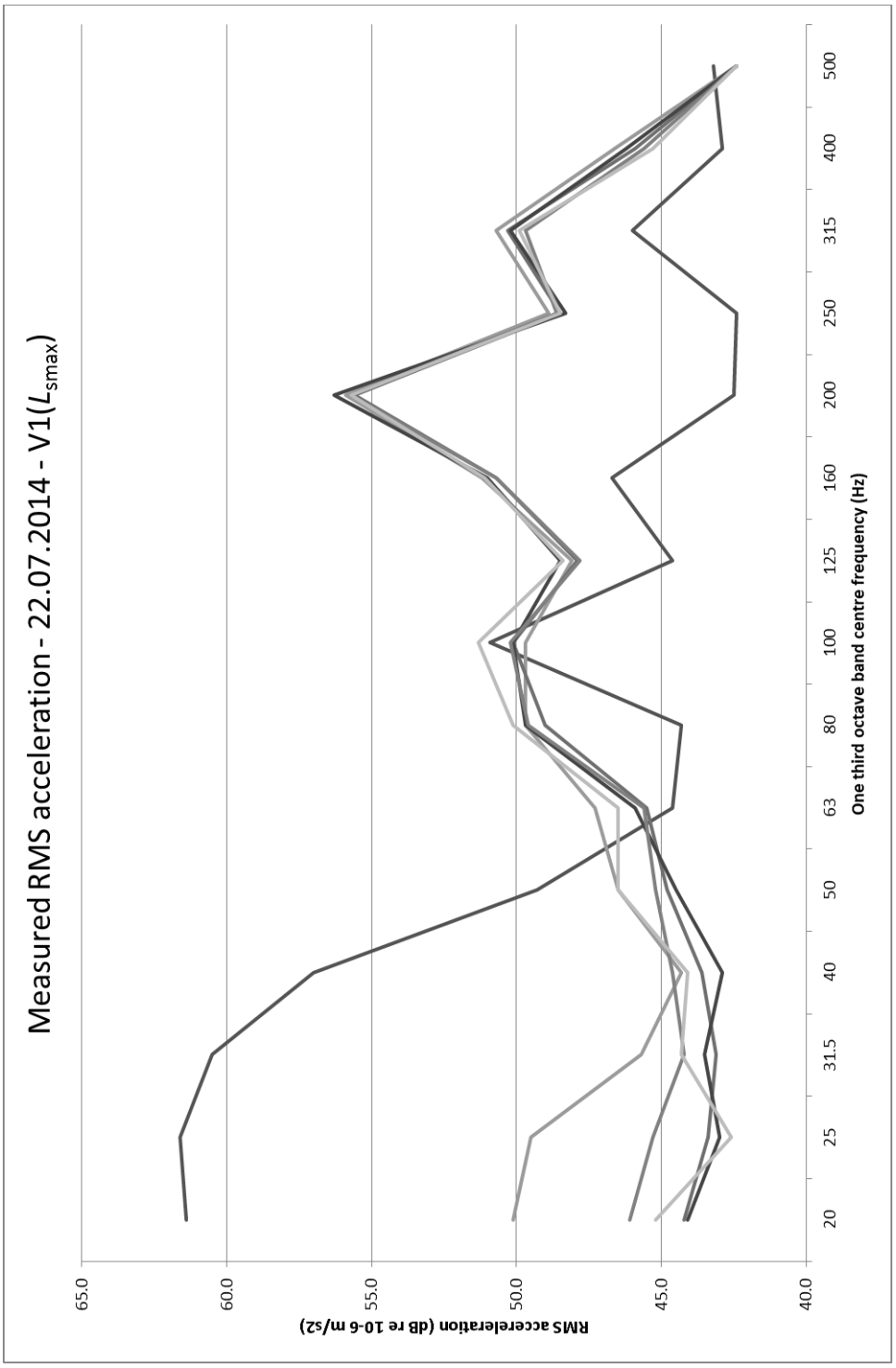
VDV measurement results

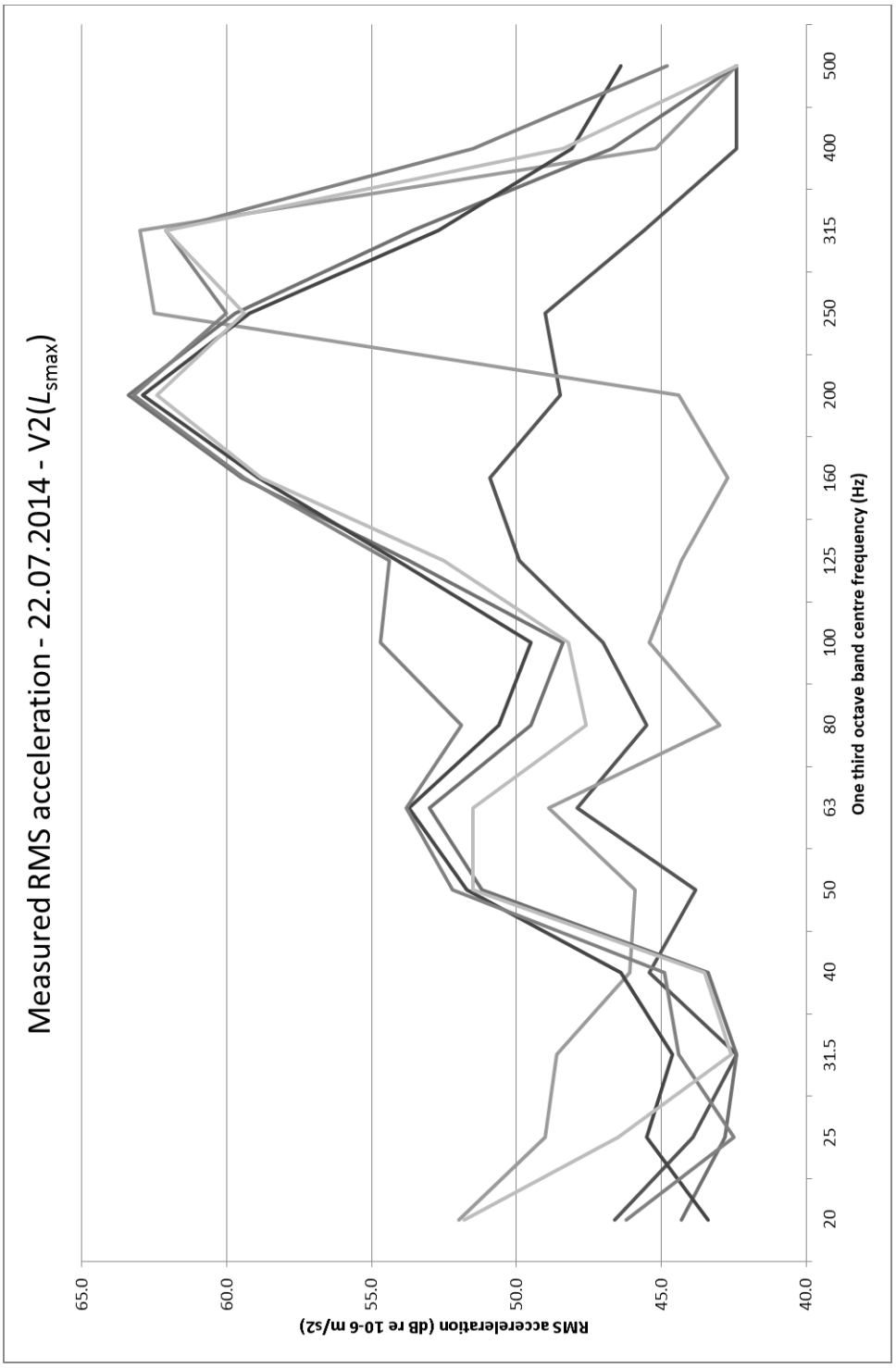
Table C1 VDVs measurement results

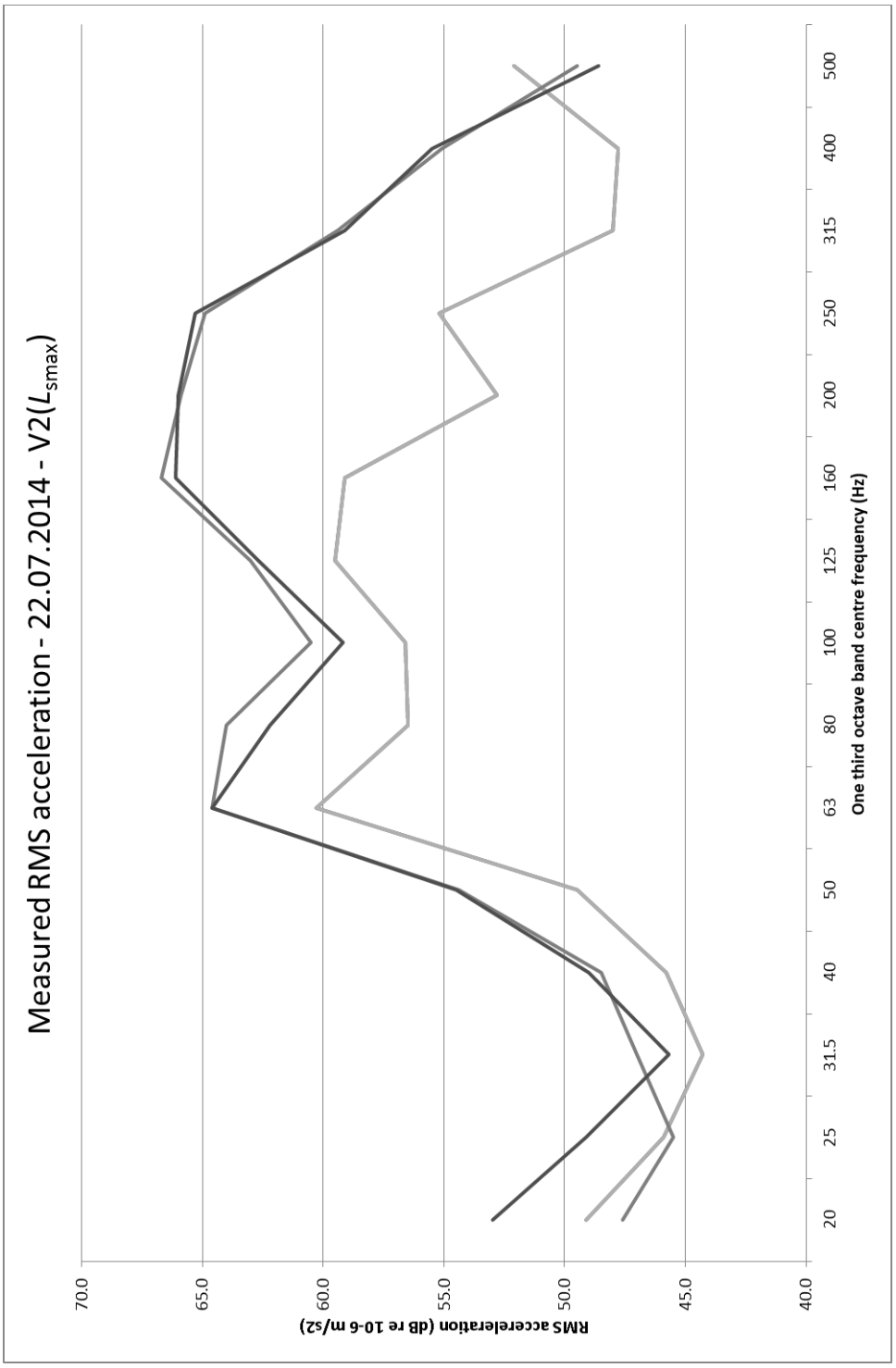
Measurement ref	VDV ($m/s^{1.75}$)		
	X axis (horizontal)	Y axis (horizontal)	Z axis (vertical)
		Location V1	
1	0.0005	0.0006	0.001
2	0.0005	0.0005	0.001
3	0.0003	0.0005	0.001
4	0.0005	0.0009	0.003
5	0.0004	0.0005	0.002
6	0.0004	0.0006	0.002
		Location V2	
7	0.0005	0.0005	0.0010
8	0.0004	0.0005	0.0010
9	0.0004	0.0005	0.0010
10	0.0005	0.0005	0.0020
11	0.0005	0.0005	0.0007
12	0.0004	0.0004	0.0010
		Location V3	
13	0.0005	0.00080	0.0020
14	0.0006	0.00070	0.0020
15	0.0005	0.00100	0.0040
16	0.0006	0.00100	0.0030
		Location V4	
17	0.0006	0.0020	0.0080
18	0.0006	0.0008	0.0050
19	0.0010	0.0009	0.0060
20	0.0020	0.0010	0.0100
21	0.0010	0.0009	0.0070
22	0.0010	0.0010	0.0090

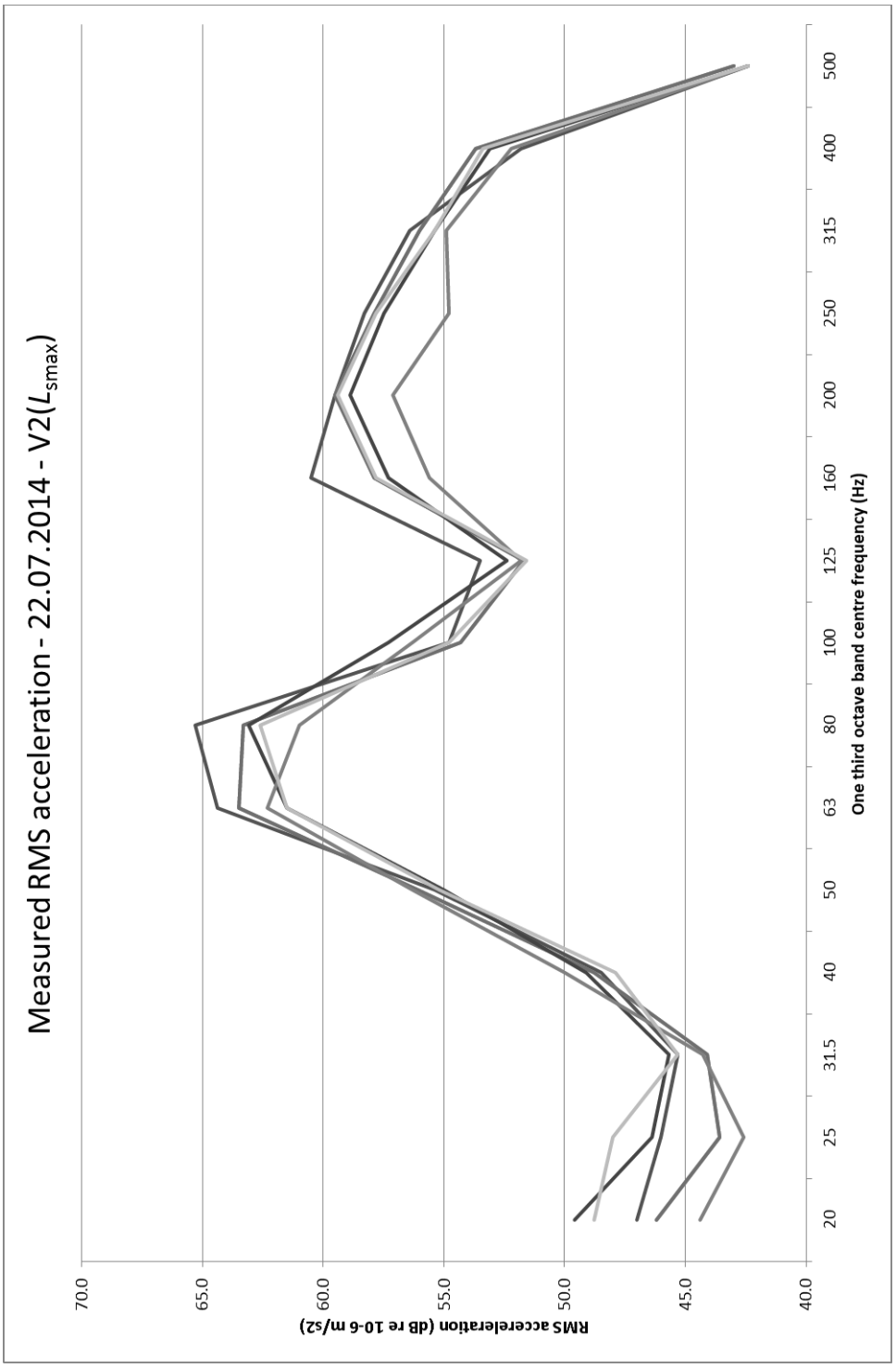
Appendix D

RMS acceleration measurement results


Measured RMS acceleration - 22.07.2014 - V1(L_{smax})
RMS acceleration (dB re 10-6 m/s2)
65.0
60.0
55.0
50.0
45.0
40.0
One third octave band centre frequency (Hz)
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500


Measured RMS acceleration - 22.07.2014 - V2(L_{smax})
RMS acceleration (dB re 10-6 m/s2)
65.0
60.0
55.0
50.0
45.0
40.0
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
One third octave band centre frequency (Hz)


Measured RMS acceleration - 22.07.2014 - V2(L_{smax})
RMS acceleration (dB re 10-6 m/s2)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
One third octave band centre frequency (Hz)


Measured RMS acceleration - 22.07.2014 - V2(L_{smax})
RMS acceleleration (dB re 10-6 m/s2)
70.0
65.0
60.0
55.0
50.0
45.0
40.0
20
25
31.5
40
50
63
80
100
125
160
200
250
315
400
500
One third octave band centre frequency (Hz)