14-16 BETTERTON STREET LONDON

ACOUSTIC ASSESSMENT REPORT

REPORT 7431/AAR
Prepared: 11 April 2017
Revision Number: 1

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Revision	Comment	Date	Prepared By	Approved By
0	First Issue	1 December 2016	Andrew Heath	Robert Barlow
1	Planning Issue	11 April 2017	Andrew Heath	Robert Barlow

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The recommendations within this report relate to acoustics performance only and will need to be integrated within the overall design by the lead designer to incorporate all other design disciplines such as fire, structural integrity, setting-out, etc. Similarly, any sketches appended to this report illustrate acoustic principles only and again will need to be developed in to full working drawings by the lead designer to incorporate all other design disciplines.

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1.0 INTRODUCTION

Redevelopment of the existing buildings located at 60-70 Shorts Gardens and 14-16 Betterton Street, London WC1 is proposed. As part of the redevelopment, it is proposed to provide a two storey roof extension to both properties and the alteration of Betterton Street to create four residential units on the upper floors.

Betterton Street runs to the south of the property and is considered the dominant noise source on the southern site boundary. To the east the building overlooks a yard which houses 3 No. large UKPN transformers and some additional plant which are the main noise source for this elevation. The north facade is connected to an adjacent property.

An assessment of noise from the operation of these transformers is required in order to determine potential impact on future residential dwellings as it has previously been established that the transformers are radiating structure borne noise throughout the Betterton Street building.

This report provides an assessment of this noise and an assessment in relation to other noise levels incident on the proposed building façades and provides acoustic performance specifications such that acceptable internal noise criteria can be achieved.

This report details the results of the noise and vibration surveys at the site and sets out the acoustic performance requirements of the building fabric elements. In addition, suitable plant noise emission criteria have also been developed based upon the survey results and the likely requirements of the Local Authority.

2.0 ENVIRONMENTAL NOISE SURVEY (EXTERNAL NOISE)

2.1 Survey Methodology

General

Continuous noise monitoring was undertaken at the re-development site between Wednesday 16th November and Monday 21st November 2016 in order to determine the corresponding noise levels over typical day and night-time periods. Some rain was noted to have occurred on a number of occasions though the effect of such occurrences appears to have had a negligible impact on the results and therefore conclusions and recommendations presented herein.

Measurement Positions

Position 1 – East elevation (Transformer Yard)

A microphone was positioned on an A-frame 1m outside of a first floor window overlooking the transformer yard to the east of 14-16 Betterton Street. The results at this measurement location are considered to be subject to façade reflection effects.

Position 2 – Betterton Street

A microphone was positioned on an A-frame 1m from the southern façade of the building at second floor level, overlooking Betterton Street. The results at this measurement location are also considered to be subject to façade reflection effects.

The measurement positions are considered to be representative of worst-case noise levels incident on the proposed residential aspects of the re-development.

2.2 Site Conditions

Since the measurements were unattended it is not possible to comment upon the noise climate at each measurement position over the entire monitoring period with absolute certainty. However, during our time on site it was noted that noise levels at Measurement Position 1 were dominated by plant noise from plant items located within the transformer yard.

At Measurement Position 2 it was noted that noise levels were affected predominantly by road traffic movements along Betterton Street and pedestrians passing the building.

2.3 Results

The measured L_{Aeq}, L_{A90} and L_{Amax} 15 minute period levels are shown as time-histories on the attached Graphs 7431/G1-4. The averaged daytime and night-time L_{Aeq} noise levels (over the 5 day period) are summarised in the following Table 7431/T1 below.

Table 7431/T1 – Measured L_{Aeq} Noise Levels

Measurement Position	Measured $L_{Aeq, period}$ Noise Level (dB)	
	Daytime (07:00 – 23:00)	Night-time (23:00 – 07:00)
Position 1 – Transformer Yard	65	64
Position 2 – Betterton Street	64	59

The minimum background noise levels ($L_{A90, 15mins}$) at each measurement position are summarised in the following Table 7431/T2 below. This data can be used to set plant noise emission criteria for use in the assessment of noise emissions from any proposed plant at the development.

Table 7431/T2 – Measured Minimum $L_{A90, 15mins}$ Noise Levels

Measurement Position	Measured Minimum $L_{A90, 15mins}$ Noise Level during period (dB)	
	Daytime (07:00 – 23:00)	Night-time (23:00 – 07:00)
Position 1 – Transformer Yard	49	49
Position 2 – Betterton Street	46	44

3.0 INTERNAL NOISE & VIBRATION SURVEY

In addition to external noise measurements a series of internal noise and vibration measurements were conducted throughout the existing building to determine the extent of noise transfer from the adjacent transformer yard.

A series of noise and vibration measurements were conducted during the evening of 16th November 2016 when the existing offices were unoccupied and ambient noise levels were low.

Noise Measurements

1/3 Octave band noise measurements were undertaken in the following general areas. Due to the highly tonal nature of the noise source the sound pressure level varied significantly with only small changes in measurement position. Multiple measurements were therefore taken within each area as well as 'sweeps' throughout the areas to ensure the measurements took into account this variation.

- Mezzanine Level Stair
- 1st Floor Stair
- 2nd Floor Stair
- 3rd Floor Stair
- 1st Floor Cellular office
- 1st Floor Open plan office
- 2nd Floor Open plan office
- 3rd Floor Open plan office
- 3rd Floor Mezzanine office

The location of each noise measurement position (N1-N32) are sown on the attached Site Plans 7431/M1 to M4. Graphs showing the noise levels measured at each position are presented in the Appendix.

Vibration Measurements

Vibration measurements were also conducted at each of the above positions. The accelerometers were mounted to a block which was fixed with beeswax to each surface.

Vibration measurement positions are indicated on the attached Site Plans 7431/M1 to M4 and graphs of each measurement position are presented in the Appendix (V1 to V15).

4.0 PLANT NOISE EMISSION CRITERIA

The requirements of the Local Authority with regards to plant noise emissions are outlined in Planning Condition 5 (Application ref: 2012/1533/P for the development.

> *The level of noise emitted from the site shall not exceed 5dB above existing background noise level (LAeq) during the daytime and evening (0700-2300 hrs.) The noise level emitted from the site shall not exceed 3dB above existing background noise level during the night (2300-0700hrs.) The noise levels should be measured at one metre external to the nearest noise sensitive premises to the site. The noise level inside any living room or bedroom of the nearest noise sensitive premises shall not exceed existing noise levels when measured using Leq 5m (in the 63 Hz octave band measured using the 'fast' time constant) during the night. All noise measurements shall be taken according to BS4142:1990.*

We note that BS4142 has been superseded twice since 1990 with the latest version released in 2014.

Table 7431/T3 – Plant Noise Emission Limits

Measurement Position	L_{Aeq} Noise Level limit of all operating plant (dB) at 1m from the nearest noise sensitive façade	
	Daytime (07:00 – 23:00)	Night-time (23:00 – 07:00)
Position 1 – Transformer Yard	54	52
Position 2 – Betterton Street	51	47

In line with BS 4142, should the proposed plant be identified as having intermittent or tonal characteristics, a further penalty should be applied to any of the above proposed noise emission limits in Table 7431/T3.

Comment on Condition Wording

We note that Condition 5 appears to differ in wording compared with Camden's typical plant noise criteria which requires plant to be designed to a more stringent limit of 5dB <u>below</u> the lowest measured background noise level.

5.0 PLANNING CRITERIA

This section outlines the assessment criteria we anticipate the Local Authority will require in terms of the relevant standards. A brief explanation of the acoustic terminology used in this report is shown within Appendix A.

5.1 National Planning Policy Framework

The National Planning Policy Framework (NPPF), March 2012, sets out the Government's planning policies for England. In respect of noise, Paragraph 123 of the NPPF states the following:

Planning policies and decisions should aim to:

- Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;
- Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established;
- Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

The above presents no quantitative guidance on a site's suitability for residential development and we have therefore, for the purposes of this assessment, made reference to the following documents.

5.2 Site Specific Requirements

Transformer Noise

Initial studies at the site highlighted noise from the adjacent transformers to be a potential noise disturbance to future residential areas and we understand the Local Authority consider this to be a key outstanding concern for the project.

This report outlines details of the noise survey undertaken to determine the extent of the low frequency (100Hz) noise from the nearby transformers affecting the site. Outline acoustic details and mitigation measures are provided herein to reduce the effect of this noise.

Street Noise

Due to the level of late night noise from adjacent streets it was requested that the noise survey included measurements recorded from the site over either a Friday or Saturday evening to demonstrate these impacts.

6.0 EXTERNAL BUILDING FABRIC CRITERIA

This section outlines the assessment criteria we anticipate the Local Authority will require in terms of the relevant standards.

6.1 British Standard 8233:2014

BS 8233:2014 *Guidance on Sound insulation and noise reduction for buildings* draws on the results of research and experience to provide information on achieving internal acoustic environments appropriate to their functions.

The noise level values given are in terms of an average (L_{Aeq}) level.

The standard advises the following internal ambient noise levels for achieving suitable resting and sleeping conditions within residential properties. A brief explanation of the acoustic terminology used in this report is shown in Appendix A attached.

Table 7431/T4 – BS 8233:2014 Residential Criteria

Room	07:00 to 23:00	23:00 to 07:00
Living Rooms	35 dB $L_{Aeq,16hour}$	--
Dining Room/area	40 dB $L_{Aeq,16hour}$	--
Bedrooms	35dB $L_{Aeq,16hour}$	30 dB $L_{Aeq,8hour}$

6.2 World Health Organisation: Guidelines for Community Noise

The document describes guideline levels that are *"essentially values for the onset of health effects from noise exposure".*

A table of guideline values is included, relating to adverse health effects, referred to as any temporary or long term deterioration in physical, psychological, or social functioning that is associated with noise exposure.

The following is an extract from *Table 4.1: Guideline values for community noise in specific environments*, as stated in the document.

Table 7431/T5 – Guideline Values for Community Noise

Specific Environment	Critical Health Effect(s)	L_{Aeq} (dB)	Time Base (hours)	$L_{Amax,f}$ (dB)
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	-
Inside bedrooms	Sleep disturbance, night-times	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60

With reference to maximum noise levels the following guidance is provided within the WHO guidance:

> *"For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45dB L_{Amax} more than 10-15 times per night (Vallet & Vernet 1991) and most studies show an increase in the percentage of awakenings at SEL values of 55-60 dBA (Passchier-Vermeer 1993; Finegold et al. 1994; Pearsons et al. 1995). For intermittent events that approximate aircraft noise, with an effective duration of 10-30s, SEL values of 55-60 corresponds to a L_{Amax} value of 45dB. Ten to 15 of these events during an 8 hour night-time implies a $L_{Aeq,\ 8h}$ of 20-25dB. This is 10-15dB below the $L_{Aeq,\ 8h}$ or 30dB for continuous night-time noise exposure, and shows that intermittent character of noise must be taken into account when setting night-time noise limits for noise exposure. For example, this can be achieved by considering the number of noise events and the difference between the maximum sound pressure level and the background of these events."*

Therefore the frequency of occurrence of maximum noise events should not typically exceed 10-15 times in any night.

6.3 Structure-Borne Noise Intrusion

With regards to structure-borne noise from plant adopting the levels in BS8233 & WHO would underestimate the noise from such sources. As such we would typically propose that noise transfer to internal areas do not exceed the following levels taking into account the tonal nature of the source.

Table 7431/T6– Ideal Target Internal Noise Limits due to Structural Noise

Area	Target Noise Criteria (NR)
Bedrooms	10
Living Rooms	15

6.4 Summary

The project criteria adopted are therefore as follows;

Bedroom	Night-time (23:00-07:00)	30dB L_{Aeq} 45dB $L_{Amax,f}$
	Plant Noise Intrusive Limit	NR10
Living Rooms	Daytime (07:00-23:00)	35dB L_{Aeq}
	Plant Noise Intrusive Limit	NR15

7.0 VIBRATION ISOLATION MEASURES

In addition to the above external fabric treatments it is recommended that vibration isolation measures be adopted in order to reduce vibration and re-radiated noise from the transformers.

The results of the noise and vibration surveys undertaken at the site (see Graphs N1-N32 and V1-V15) suggest that re-radiated noise levels do not decrease throughout the building and in fact higher intrusive noise and vibration levels were measured within 3rd floor areas. It is therefore recommended that vibration isolation measures be incorporated to ensure suitable internal noise levels for all residential areas of the building.

7.1 Isolation of Transformers

We re-iterate our previous comments on this issue that the first solution to be considered in terms of feasibility is isolation of the transformers themselves. We are aware of situations where it has been considered most appropriate to retrospectively fit high performance vibration isolators to the transformers to attenuate the noise / vibration at source.

We understand the transformers may be due for refurbishment/replacement but the timescales for this are currently unknown. It is also unclear as to whether UKPN would consider the inclusion of vibration isolation and would naturally requires a high degree of co-operation from them.

We still recommend that further contact with UKPN be sought but consider that this option cannot be fully relied upon.

7.2 Structural Solution

Box-within-Box

If attenuation of the transformers at source cannot be undertaken then the isolation of the future residential rooms from the existing structures would be required. Although the overall noise level internally is low, the tonal sound energy at 100Hz is such that around 20dB attenuation at this particular frequency is required. This required reduction is significant and substantial works would be necessary to the existing building to provide such a reduction.

The most appropriate solution is considered to construct a box-within-box type structure for each residential location. The principle of a box-within-box is to ensure the internal walls, floors and ceilings of future rooms are fully independent of the existing supporting structures. Figure 7431/D1 shows the proposed isolation solution.

Treatment to the floor would typically comprise the following (assuming no wet trades);

- 18mm Plywood or chipboard flooring
- 4 layers of 10mm Cement particle board
- 18mm Plywood or chipboard flooring
- 50mm x 50mm x 50mm elastomeric isolation bearings (e.g. Sylomer SR450)
- 50mm mineral wool insulation between bearings

The walls would be built from the above floating floor and comprise a minimum 3 layers of 15mm SoundBloc plasterboard fixed to the studwork with mineral fibre between studs. The ceiling would comprise a minimum 3 layers of 15mm SoundBloc plasterboard with mineral wool above supported on spring isolation hangers.

Floor Void Openings

An important aspect to take into account when considering floating floors/box-in-box solutions is the depth of air in the floor void cavity. When small areas of air (a depth of less than around 100mm) are compressed within a floor void it can behave like a spring and can reduce the performance of floating floors (particularly lightweight systems). To reduce this effect the floor voids must be open into adjacent wall cavities to allow the air to 'vent' around. The principles of this are indicated on Figure 7431/D1.

7.3 Treatment of Stairs

Initial comments from the Local Authority have suggested that isolation measures should also be incorporated to the stairs. We would challenge this recommendation as common areas are not normally considered to be noise sensitive spaces and people spend less time in them.

We understand one particular concern relates to re-radiated noise manifesting in an un-isolated stair and transferring to isolated habitable rooms. We consider the likelihood of this occurring to be minimal as we would expect the noise loss through the door and into the habitable rooms to be low, particularly as the areas directly on to the stairs are likely to be corridors/entrance halls within the flats.

We would therefore recommend that the stairs are not isolated but to ensure this noise path is as well controlled as possible. On this basis we would recommend the flat entrance doors comprise higher performance doors than typically required to satisfy Building Regulations standards and that the common parts should have suitable absorptive finishes in order to control reverberant noise build up within the space.

We recommend the doors be rated at R_w 35 dB which can typically be achieved using a 54mm solid core timber door with full perimeter seals. Absorptive ceilings and carpeted floors should be allowed for in the entrance stairs.

Drawing 7431/D2 outlines the indicative junction between an isolated flat and un-isolated stair.

7.4 Secondary Glazing

To control airborne noise intrusion for windows overlooking the transformer yard we would recommend secondary glazing as indicated on Drawing 7431/D3. The secondary pane should be fixed closed and spaced a minimum 200mm from the external pane. It should also be offset from vertical by approximately 5 degrees and the reveals should be acoustically lined. The window frames should be fully isolated from the surrounding masonry external walls.

8.0 EXTERNAL BUILDING FABRIC ASSESSMENT

8.1 Background

Appropriate internal noise levels can be achieved providing suitable building envelope constructions are employed.

Analyses of the external building fabric have been undertaken in order to ascertain the required acoustic performance of the glazing and other external fabric elements to achieve the project criteria.

8.2 Assumptions

Our external building fabric analyses have assumed the following:

(a) Noise Levels

The assessment has been based on the measured noise levels as detailed in Section 2.3.

(b) Room Absorption

We have assumed the bedrooms to be acoustically "soft" with carpets, curtains and other soft furnishings. For the purposes of our analyses we have assumed the following absorption coefficients.

Table 7431/T7 – Bedroom Absorption Coefficients

Absorption Coefficient (α) at Octave Band Centre Frequency (Hz)							
63	125	250	500	1k	2k	4k	8k
0.15	0.18	0.25	0.27	0.31	0.32	0.32	0.32

We have assumed the living rooms to be less acoustically absorptive (with a hard floor finish, although with furnishings). For the purposes of our analyses we have assumed the following absorption coefficients.

Table 7431/T8 – Living Room Absorption Coefficients

Absorption Coefficient (α) at Octave Band Centre Frequency (Hz)							
63	125	250	500	1k	2k	4k	8k
0.15	0.18	0.20	0.22	0.22	0.22	0.23	0.27

(c) External Wall

We understand that external non-glazed areas are to comprise the following:

- Existing external masonry walls
- Isolated box-in-box system comprising
- 3 layers 15mm dense plasterboard (min 12.5kg/m^2 per board)

As such, we have assumed the following sound reduction indices (equating to an overall R_w of 75dB) for all non-glazed façade areas comprising the above construction:

Table 7431/T9 – Non-Glazed SRIs

Assumed Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)							
63	125	250	500	1k	2k	4k	8k
40	51	64	73	81	85	85	85

(d) Ventilation

It is understood that a "whole-house" mechanical ventilation (WHMV – Approved Document F System 4) system is proposed throughout the development. This comprises a low speed encased fan within a fully ducted system with fresh air supply to bedrooms and living rooms and extract from kitchens and toilets/bathrooms. It is typical for the WHMV system to also have heat recovery (i.e. MVHR) capabilities for increased SAP ratings. We have assumed that external noise break-in to the bedrooms and living rooms via the ventilation system will be negligible (when compared to the glazing) due to the fully ducted nature of the system. We would suggest that intake air is not taken from the façade facing the Transformer Yard.

Fan Coil Units (FCUs) are also currently proposed for cooling purposes.

Should the proposals for ventilation change to include mechanisms such as trickle vents, it is important that RBA Acoustics is informed at the earliest opportunity as alternative vents could have a significant impact on the sound insulation performance for the building.

8.3 Guidance Constructions

For guidance purposes we would typically expect the following glazing configurations detailed below to prove commensurate with achieving the sound insulation performance requirements.

A further detailed external building fabric analysis will be carried out at detailed design stage which will outline full acoustic specifications of each glazing type.

Table 7431/T10 – Glazing Guidance Constructions

Glazing Type	Glazing Configuration
G1	Secondary glazing as outlined in Section 7.4
G2	High specification double glazing comprising 10mm glass / 12mm cavity / 6.4mm laminated glass
G3	Double Glazing comprising 8mm glass / 12mm cavity / 4mm glass

8.4 Applicable Zoning

Due to the differences in the prevailing noise climate around the site, three primary glazing zones have been defined, as indicated on the attached Façade Zoning Plan 7431/FZ1.

(i) Zone 1 – Glazing Type: G1

(ii) Zone 2 – Glazing Type: G2

(iii) Zone 3 – Glazing Type: G3

9.0 CONCLUSION

RBA Acoustics have undertaken noise and vibration monitoring at the proposed development site at 14-16 Betterton Street, London. The measured noise levels are presented herein.

The resultant noise levels have been used in our assessment of the building fabric requirements to ensure suitable internal noise levels are achieved at the proposed development with reference to BS 8233 and WHO.

Internal noise and vibration measurement have been used to determine the extent of noise break-in from the adjacent transformer yard to the east of the site. Noise and vibration levels remain high throughout the building and warrant the installation of specialist vibration isolation measures in order to ensure suitable internal noise levels within proposed residential spaces. Indicative vibration isolation measures have been proposed herein.

General guidance configurations have also been suggested for the glazing constructions to ensure noise break-in from external noise sources are suitably controlled.

The data has also been used to set plant noise emission criteria for future assessment of any proposed plant at the development to ensure the adjacent neighbour's amenity spaces are protected from plant noise emissions in line with the Local Authority anticipated requirements.

Appendix A - Acoustic Terminology

dB	Decibel - Used as a measurement of sound pressure level. It is the logarithmic ratio of the noise being assessed to a standard reference level.
dB(A)	The human ear is more susceptible to mid-frequency noise than the high and low frequencies. To take account of this when measuring noise, the 'A' weighting scale is used so that the measured noise corresponds roughly to the overall level of noise that is discerned by the average human. It is also possible to calculate the 'A' weighted noise level by applying certain corrections to an un-weighted spectrum. The measured or calculated 'A' weighted noise level is known as the dB(A) level. Because of being a logarithmic scale noise levels in dB(A) do not have a linear relationship to each other. For similar noises, a change in noise level of 10dB(A) represents a doubling or halving of subjective loudness. A change of 3dB(A) is just perceptible.
L_{eq}	L_{eq} is defined as a notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (1 hour).
L_{Aeq}	The level of notional steady sound which, over a stated period of time, would have the same A-weighted acoustic energy as the A-weighted fluctuating noise measured over that period.
L_{An} (e.g. L_{A10}, L_{A90})	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time, hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the average minimum level and is often used to describe the background noise.
$L_{max,T}$	The instantaneous maximum sound pressure level which occurred during the measurement period, T. It is commonly used to measure the effect of very short duration bursts of noise, such as for example sudden bangs, shouts, car horns, emergency sirens etc. which audibly stand out from the general level of, say, traffic noise, but because of their very short duration, maybe only a very small fraction of a second, may not have any effect on the L_{eq} value.

Appendix B – CDM Considerations

Having identified the hazards, a more detailed assessment of risk is necessary in order that the appropriate action may be taken. A precise estimate of risk is neither practical nor required.

The likelihood the harm will occur can be assessed by applying an indicative score (from 1 to 5) as follows:

1 – Remote (almost never)
2 – Unlikely (occurs rarely)
3 – Possible (could occur, but uncommon)
4 – Likely (recurrent but not frequent)
5 – Very likely (occurs frequently)

The severity of harm can be assessed by applying an indicative score (from 1 to 5) as follows:

1 – Trivial (e.g. discomfort, slight bruising, self-help recovery)
2 – Minor (e.g. small cut, abrasion, basic first aid need)
3 – Moderate (e.g. strain, sprain, incapacitation > 3 days)
4 – Serious (e.g. fracture, hospitalisation > 24 hrs, incapacitation > 4 weeks)
5 – Fatal (single or multiple)

The rating value is obtained by multiply the two scores and is then used to determine the course of action.

Rating Bands (Severity x Likelihood)		
Low Risk (1 – 8)	Medium Risk (9 -12)	High Risk (15 – 25)
May be ignored but ensure controls remain effective	Continue, but implement additional reasonable practicable controls where possible	Avoidance action is required; therefore alternative design solutions must be examined. Activity must not proceed until risks are reduced to a low or medium level

The following hazards pertinent to our design input have been identified and control measures suggested:

Hazard	Risk Of	At Risk	Rating			Control Measures	Controlled		
			L	S	R		L	S	R
Acoustic glazing - weight	Strain of neck, limbs or back. Fall from height.	Contractors	3	5	15	Alternative "standard" glazing has been investigated but not considered viable. Provide sufficient manpower, lifting gear and structural support	1	5	5
Mineral wool in cavities	Skin and respiratory irritation	Contractors	4	3	12	Wear gloves and mask	1	3	3
Vibration Isolators	Injury to hands	Contractors	3	3	9	Care needs to be taken during adjustment. Follow manufacturers guidance	1	3	3

L: Likelihood
S: Severity
R: Rating

Appendix C - Survey Instrumentation Details

The following equipment was used for the survey:

Table 7431/SI1 – Noise Equipment Details

Manufacturer	Model Type	Serial No.	Calibration	
			Certificate No.	Expiry Date
Norsonic Type 1 Sound Level Meter	Nor140	1405945	U21194	3 April 2018
Norsonic Pre Amplifier	1209	15800		
Norsonic ½" Microphone	1225	208218	21193	
Norsonic Sound Calibrator	1251	34057	U21192	
Norsonic Type 1 Sound Level Meter	Nor140	1406007	U21856	13 June 2018
Norsonic Pre Amplifier	1209	20043		
Norsonic ½" Microphone	1225	208146	21855	
Norsonic Sound Calibrator	1251	34127	U21854	

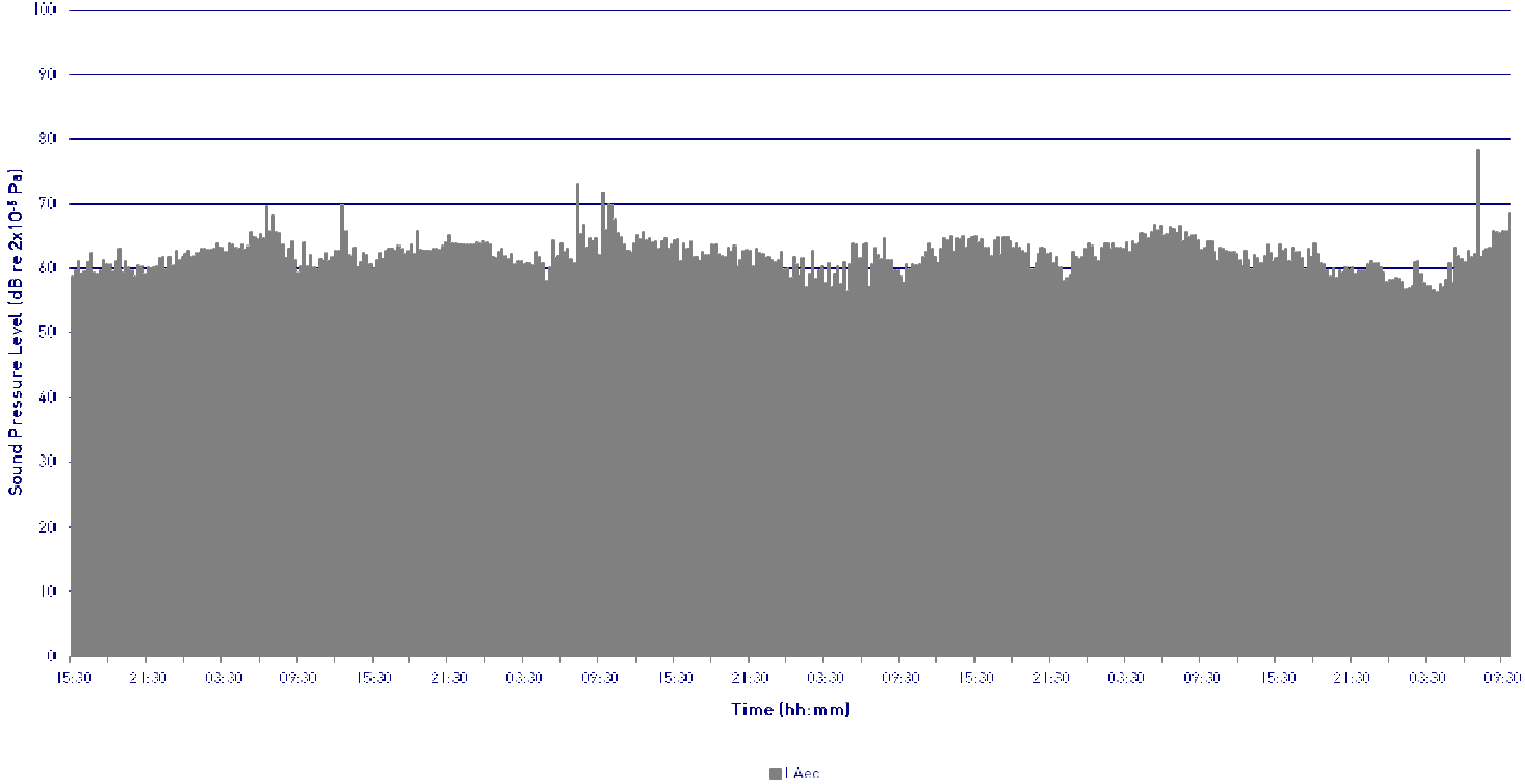
Table 7431/SI22 – Vibration Equipment Details

Manufacturer	Model Type	Serial No.	Calibration	
			Certificate No.	Valid Until
01dB A&V Measurement System	Symphonie	01743	1608450	31 August 2018
DJB Accelerometer	A/121/V	1213	1608446	30 August 2018
DJB Accelerometer	A/121/V	1264	1608447	30 August 2018
AP Vibration Calibrator	AT01	2003	1608448	30 August 2018

All equipment was calibrated both prior to and on completion of the survey with no calibration drifts observed.

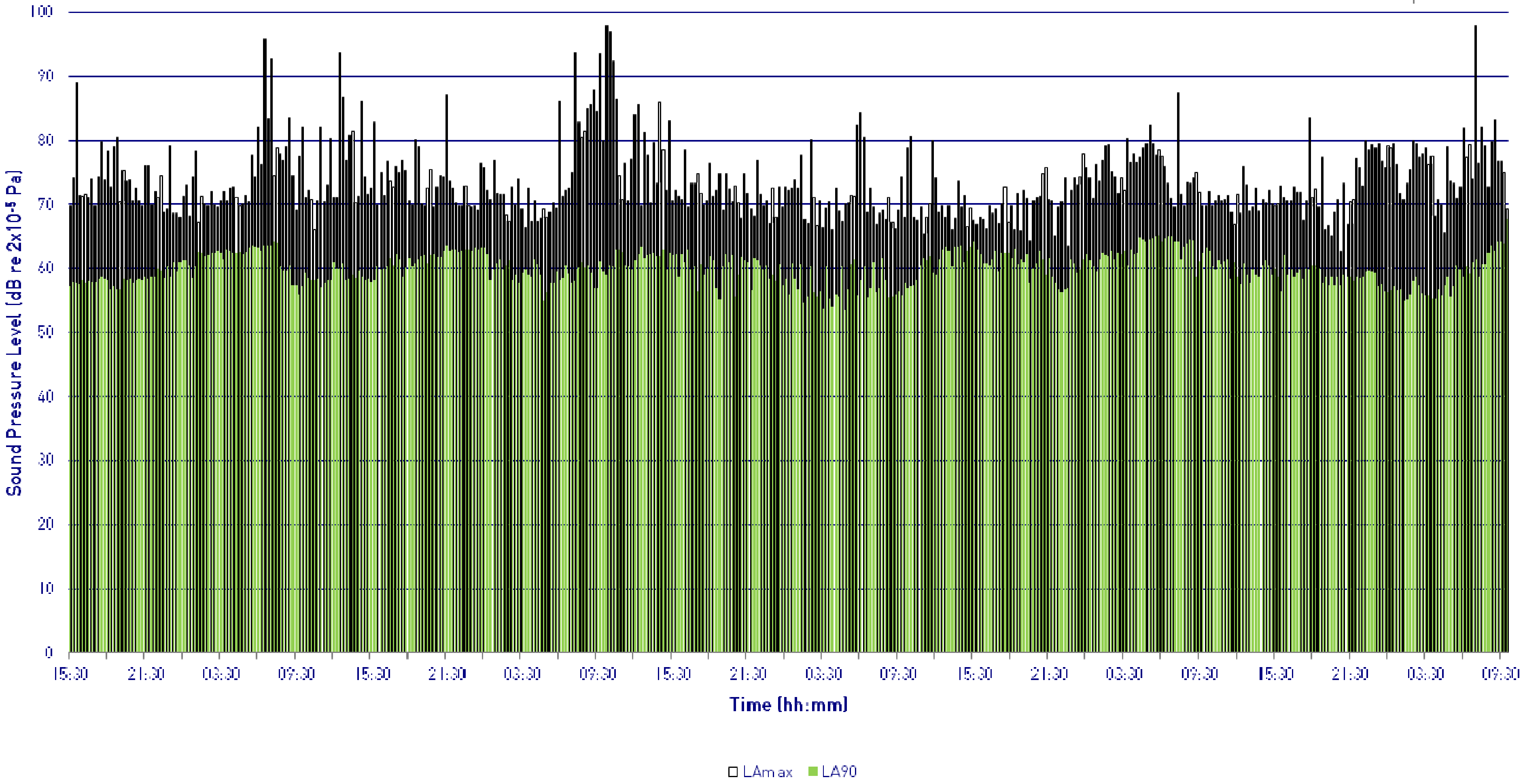
14-16 Betterton Street
Position 1 -First Floor Overlooking Transformer Yard
L_{Aeq} Time History
Wednesday 16 November to Monday 21 November 2016

Graph 7431/G1



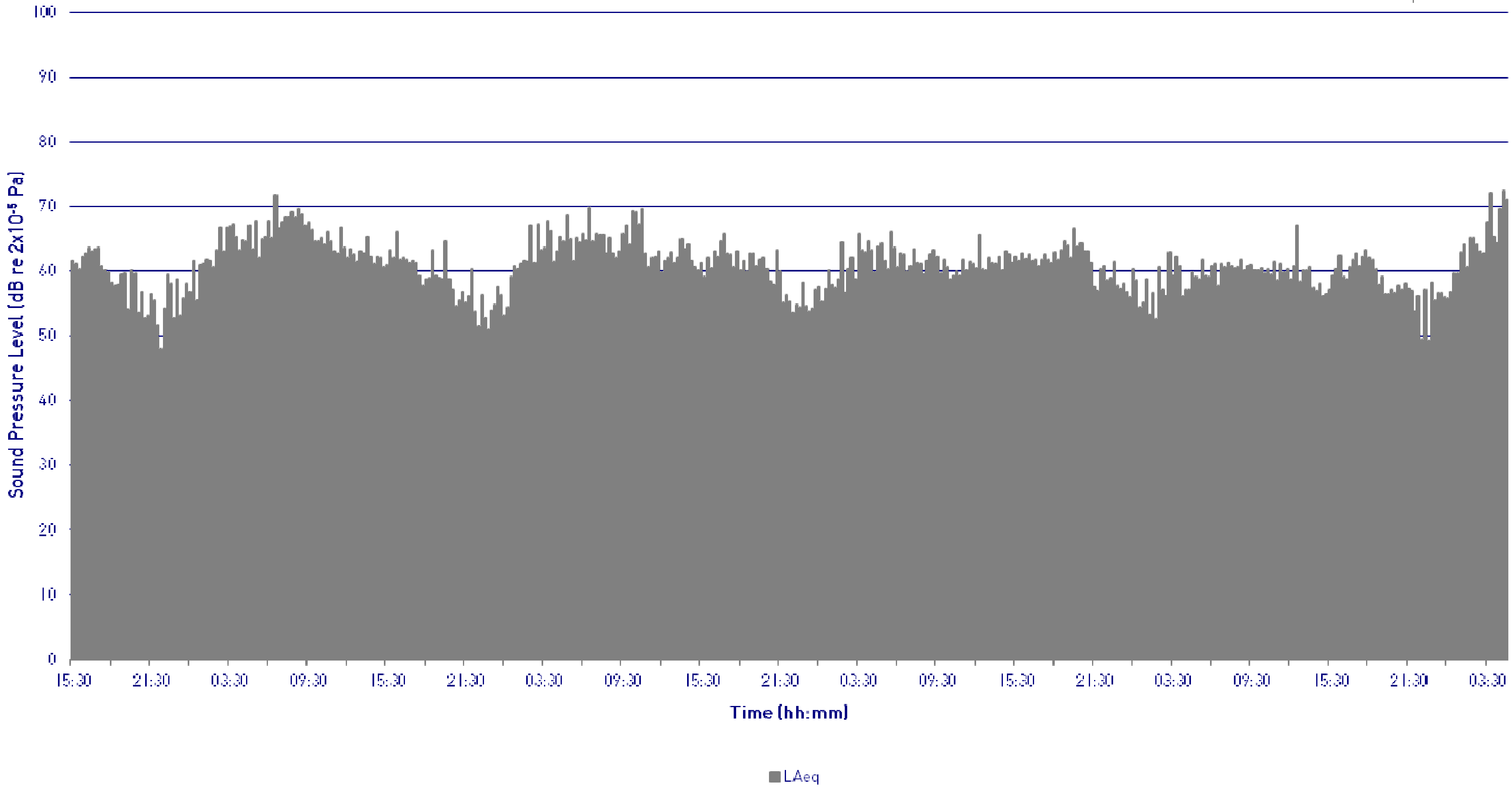
14-16 Betterton Street
Position 1 -First Floor Overlooking Transformer Yard
L_{A90} and L_{Amax} Time History
Wednesday 16 November to Monday 21 November 2016

Graph 7431/G2



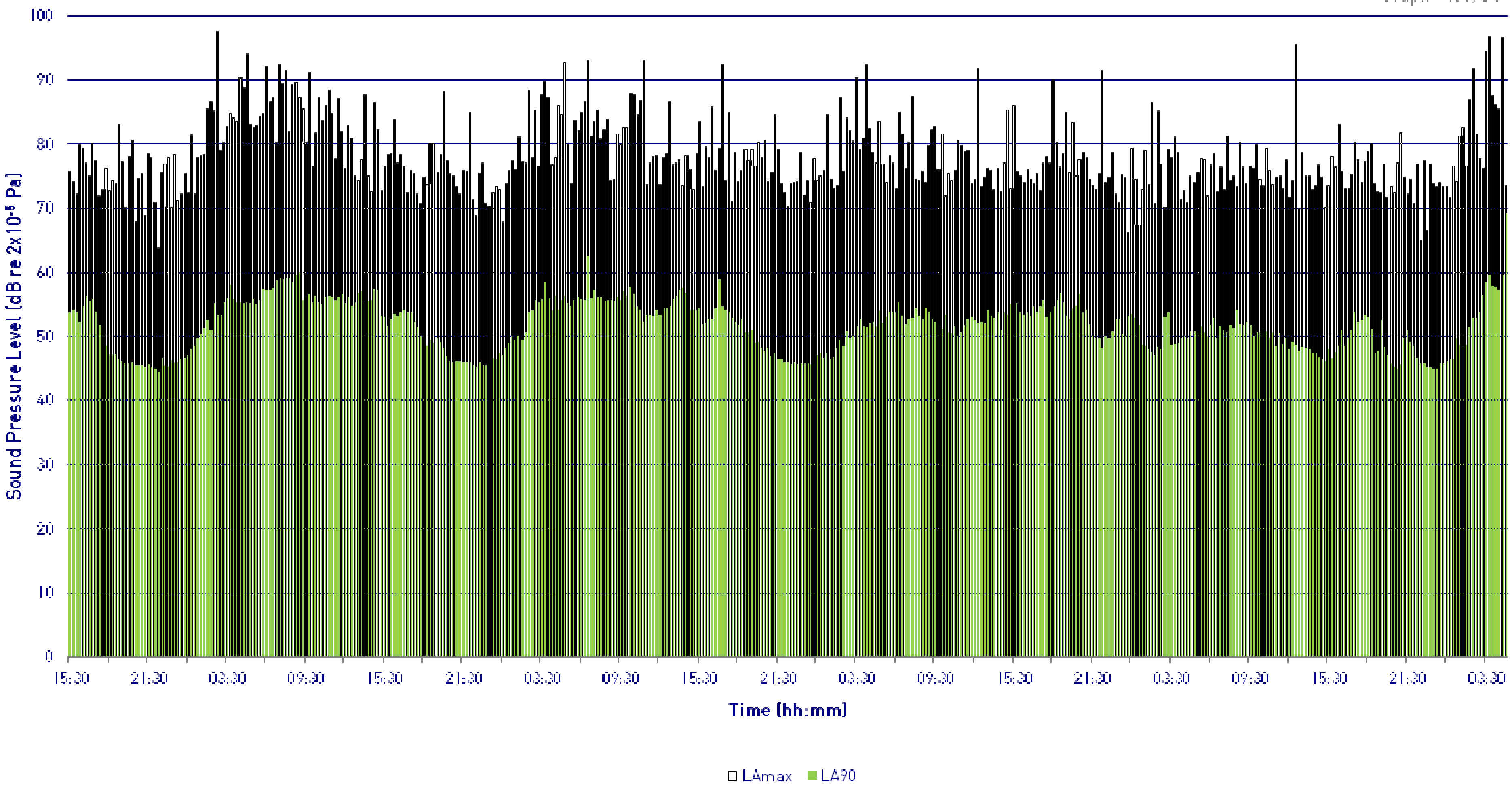
14-16 Betterton Street
Position 2 - Second Floor Overlooking Betterton Street
L_{Aeq} Time History
Wednesday 16 November to Monday 21 November 2016

Graph 7431/G3

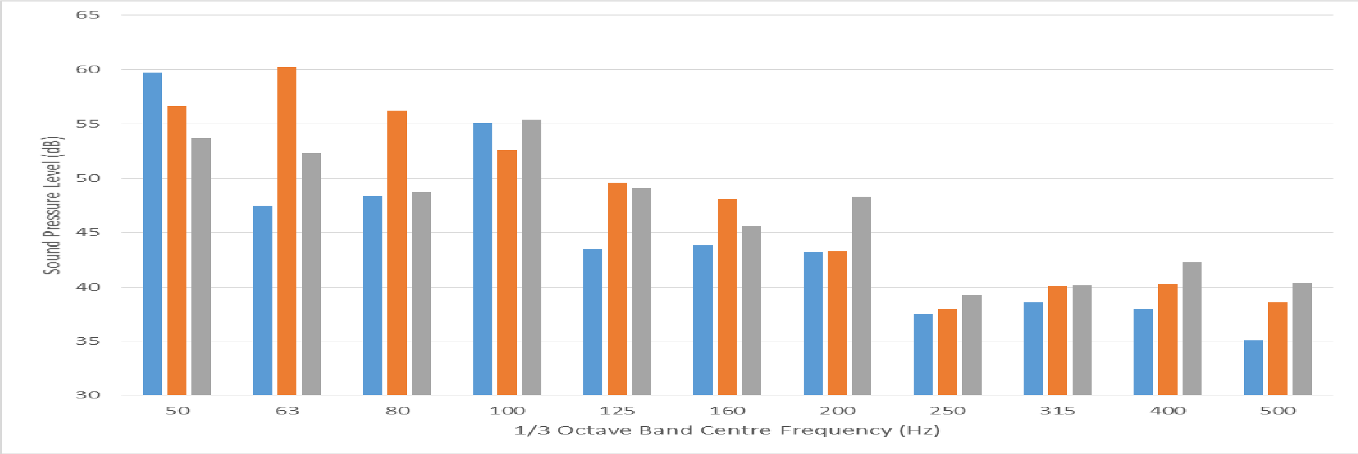


14-16 Betterton Street
Position 2 - Second Floor Overlooking Betterton Street
L_{A90} and L_{Amax} Time History
Wednesday 16 November to Monday 21 November 2016

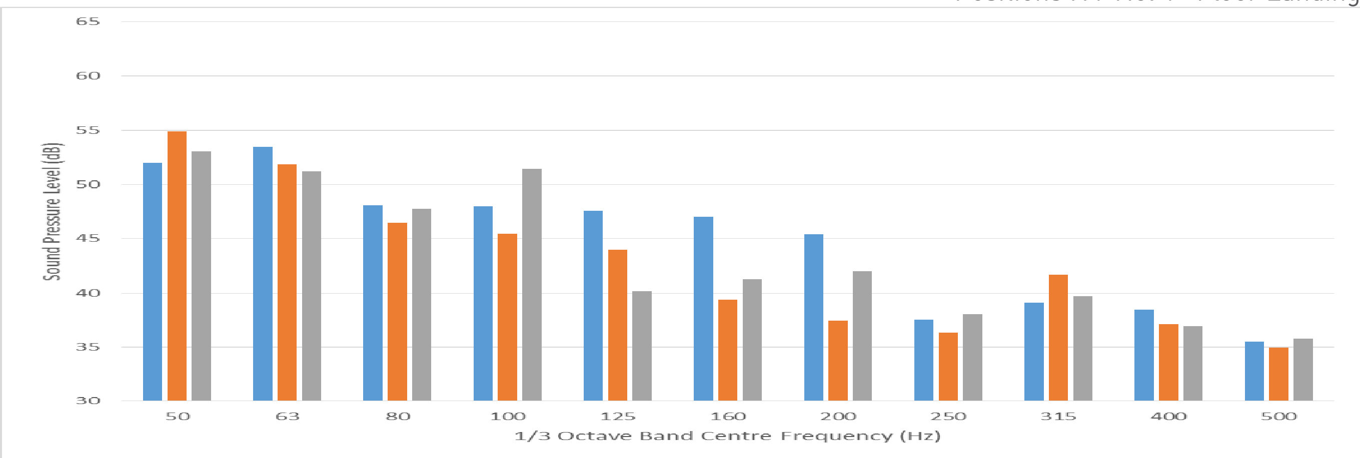
Graph 7431/G4



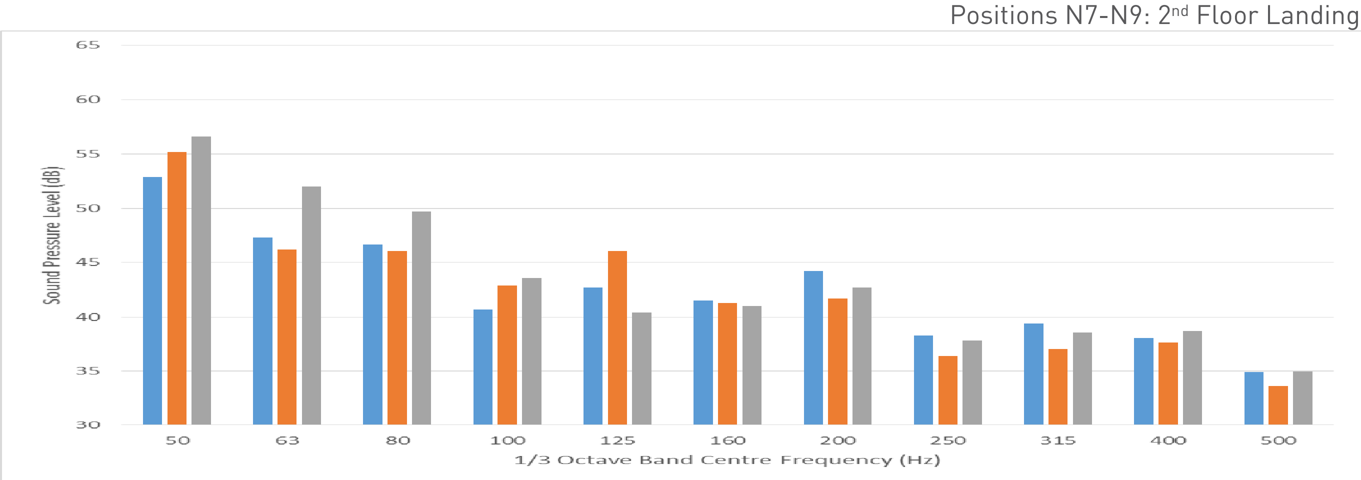
Positions N1-N3: Mezzanine Landing



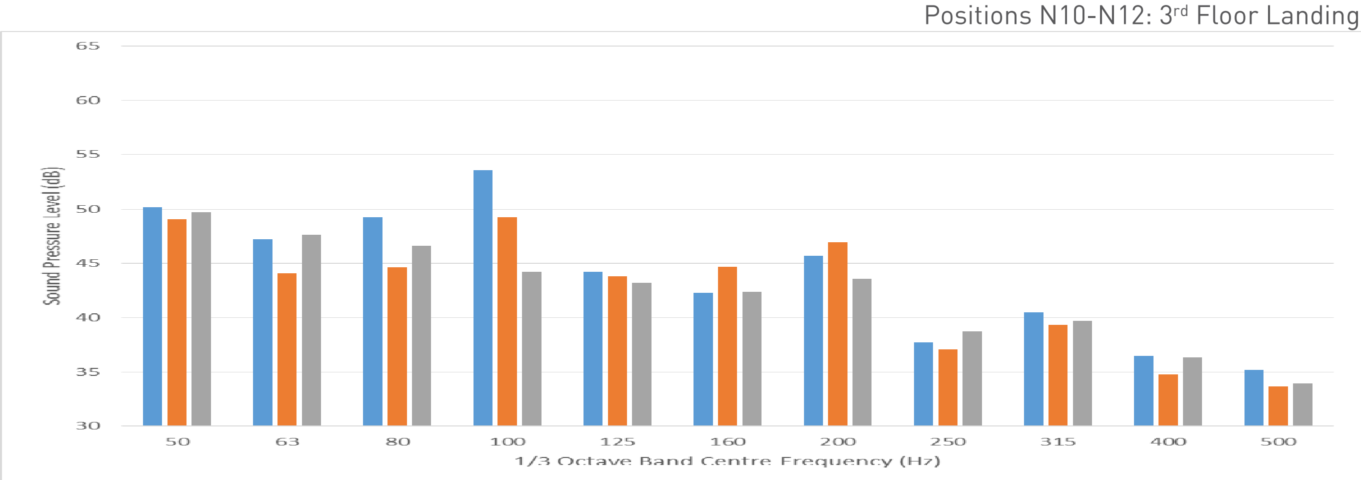
Positions N4-N6: 1st Floor Landing



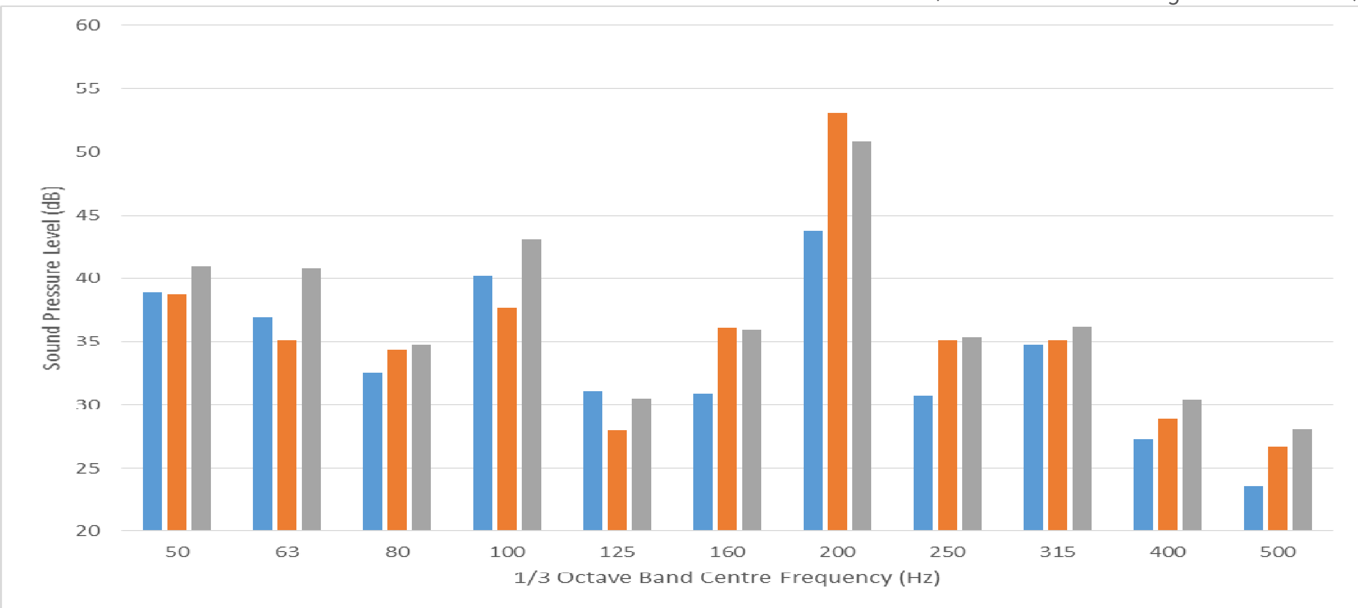
Positions N7-N9: 2nd Floor Landing



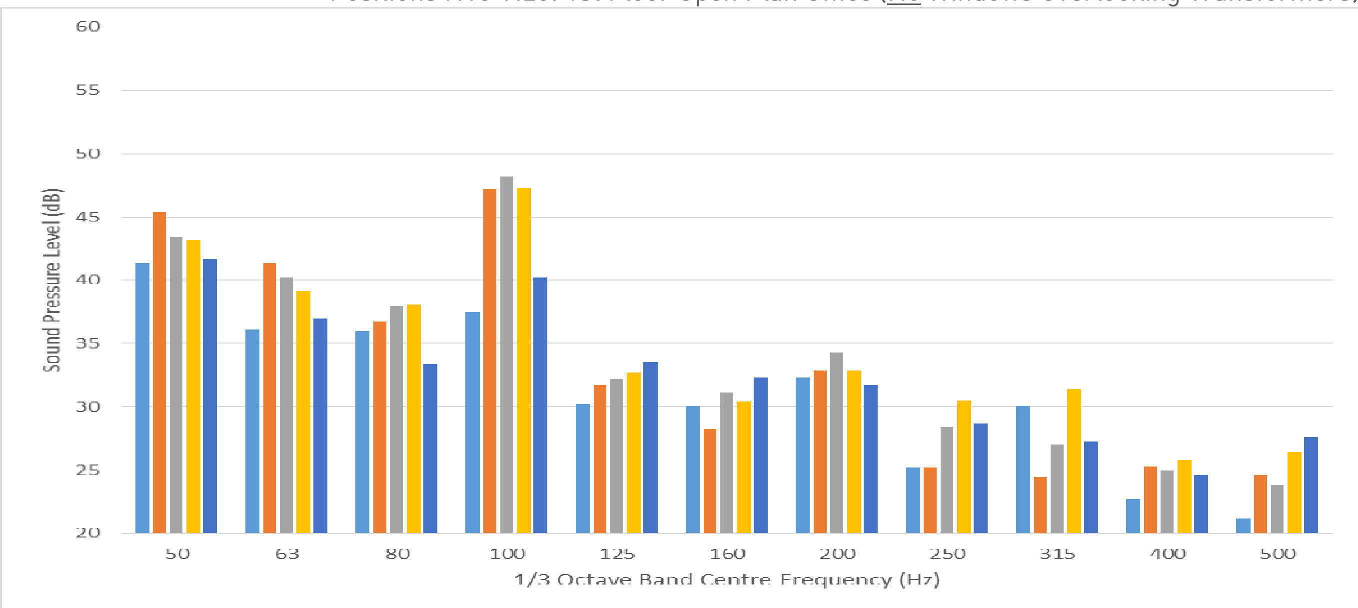
Positions N10-N12: 3rd Floor Landing



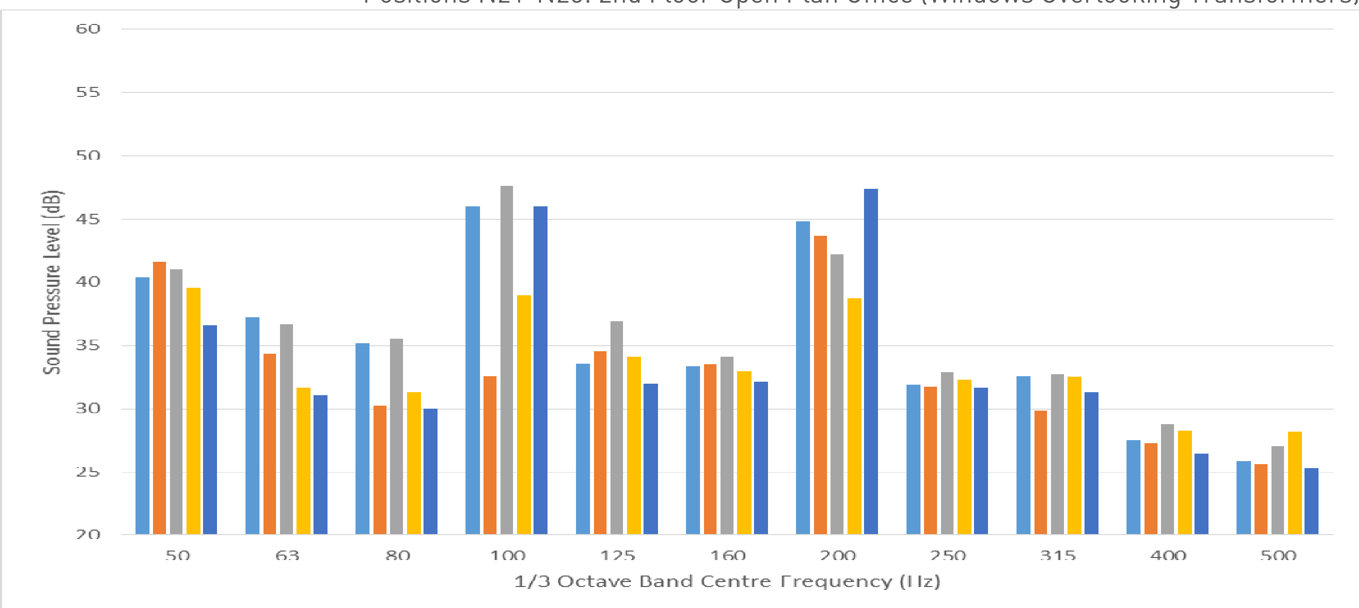
Positions N13-N15: 1st Floor Cellular Office (Window Overlooking Transformers)



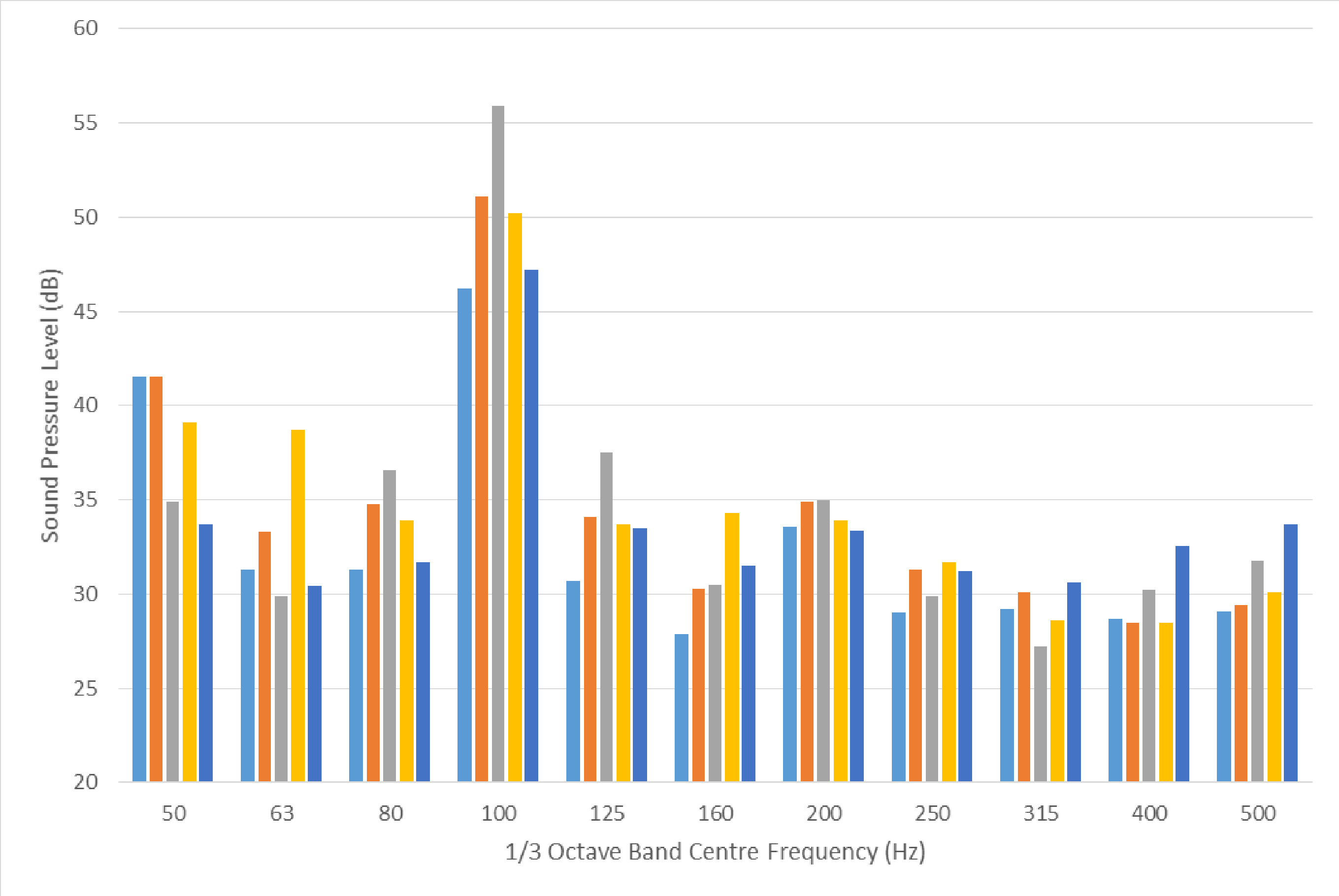
Positions N16-N20: 1st Floor Open Plan Office (No Windows Overlooking Transformers)



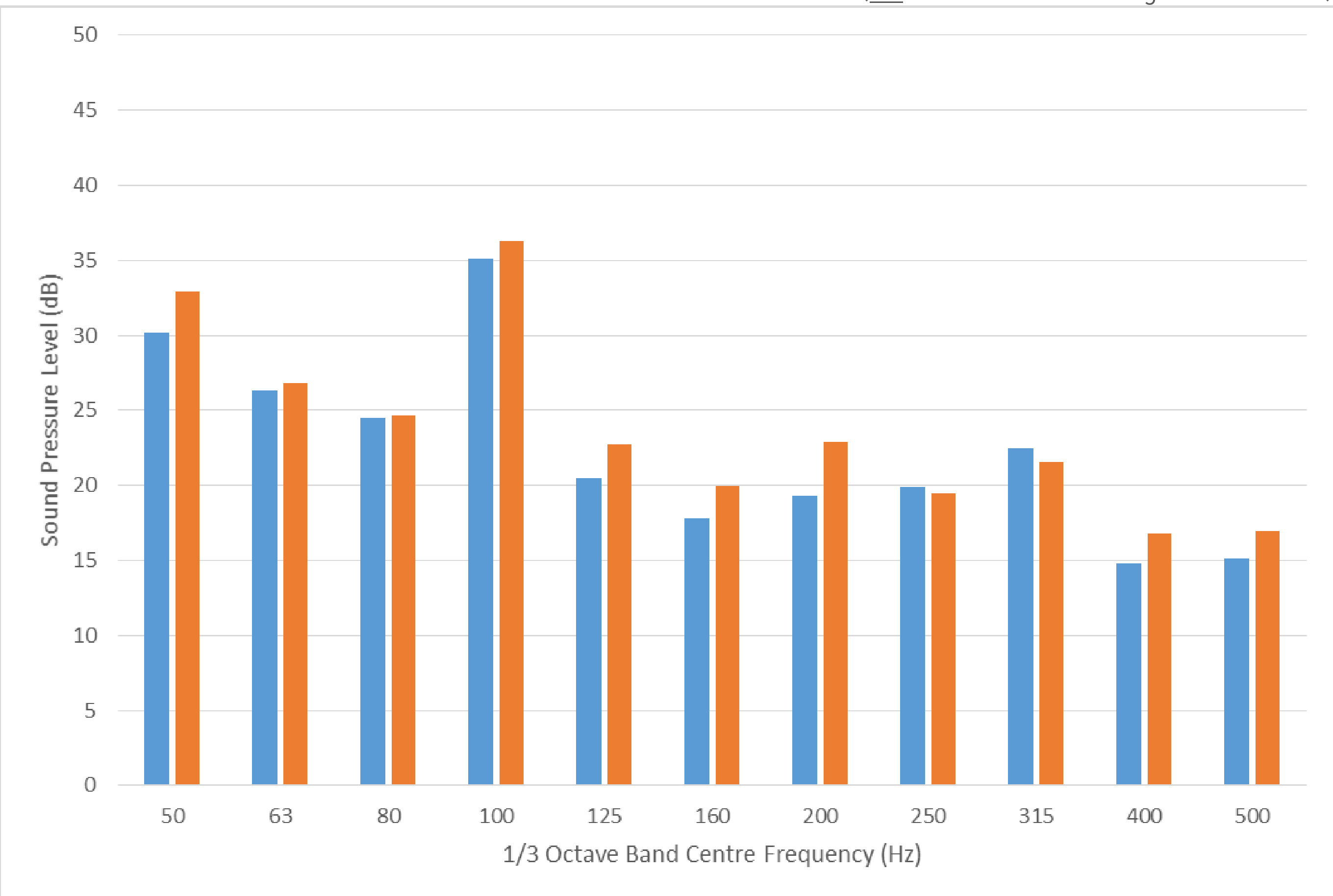
Positions N21-N25: 2nd Floor Open Plan Office (Windows Overlooking Transformers)



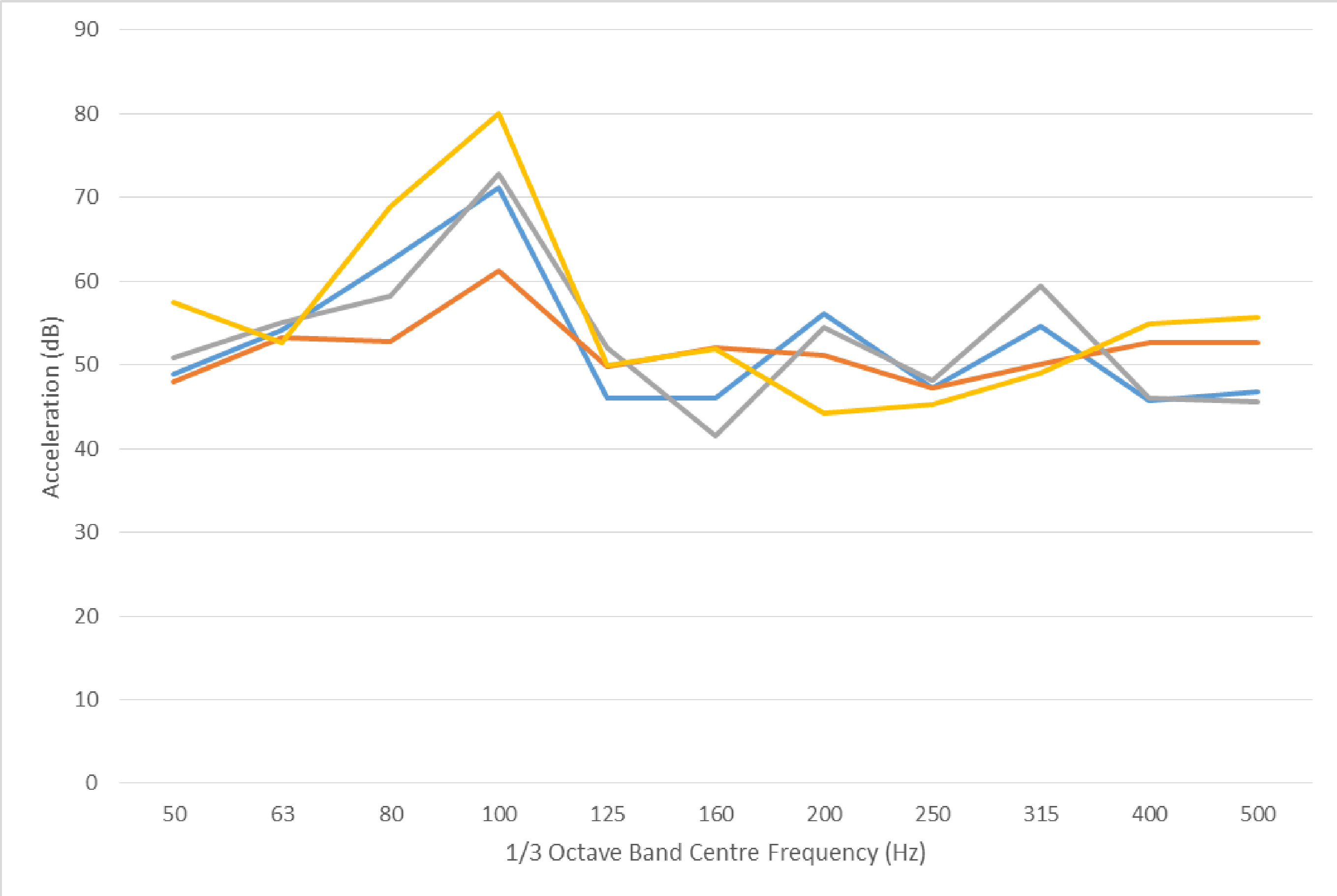
Positions N26-N30: 3rd Floor Open Plan Office (Windows Overlooking Transformers)



Positions N32-N32: 3rd Floor Mezzanine Office (No Windows Overlooking Transformers)

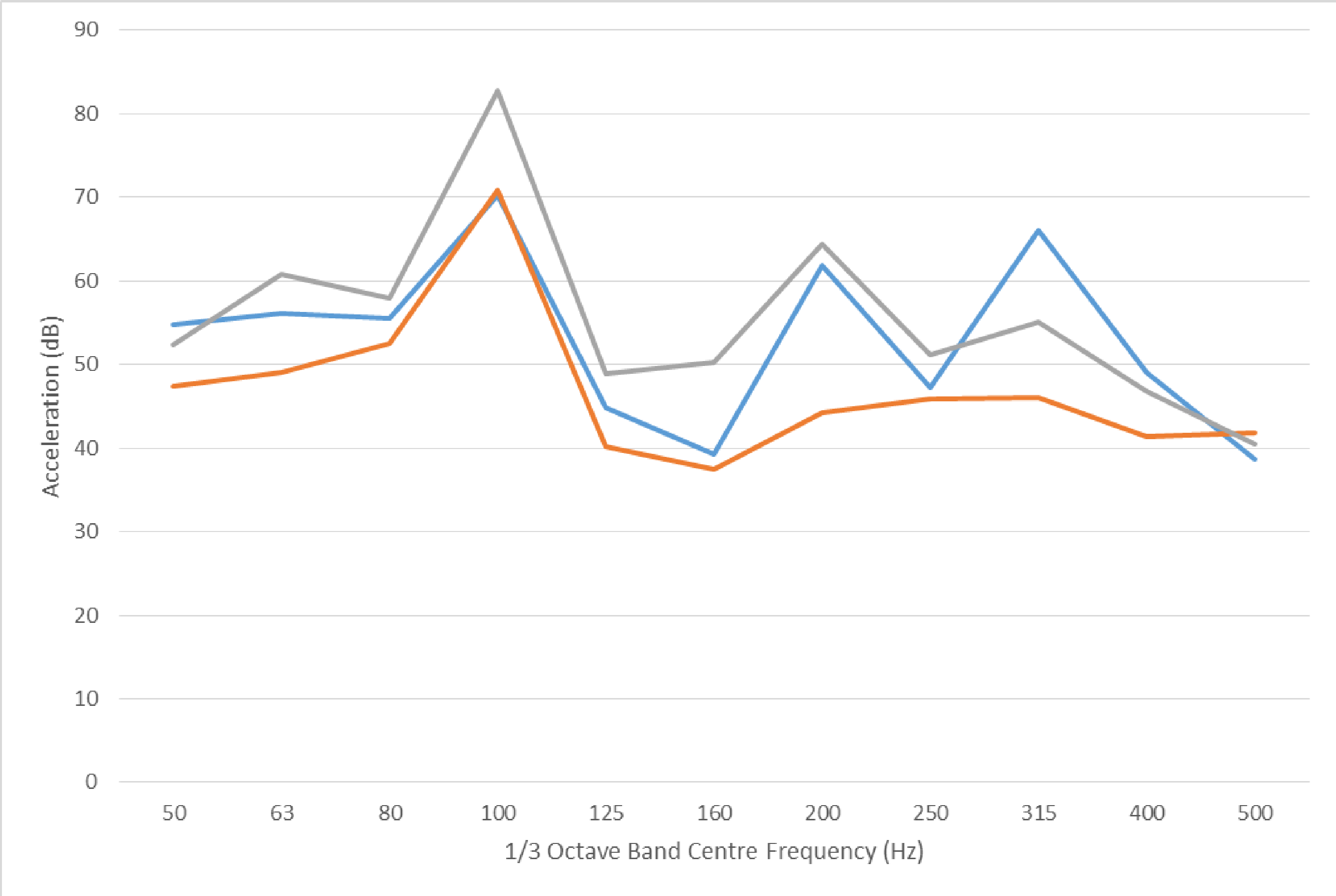


Positions V1-V4: Stairs Levels Mezzanine to 3rd Floors

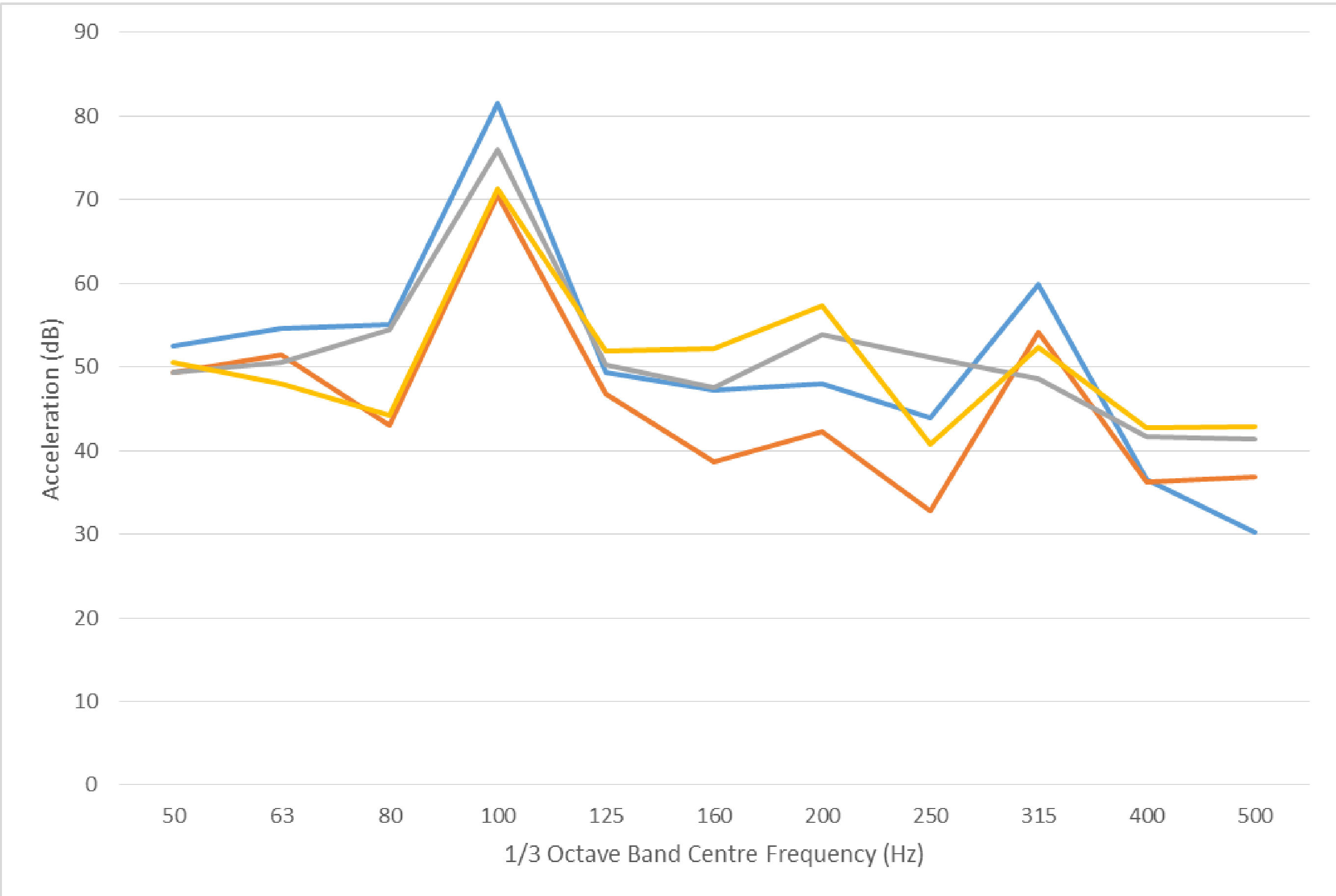


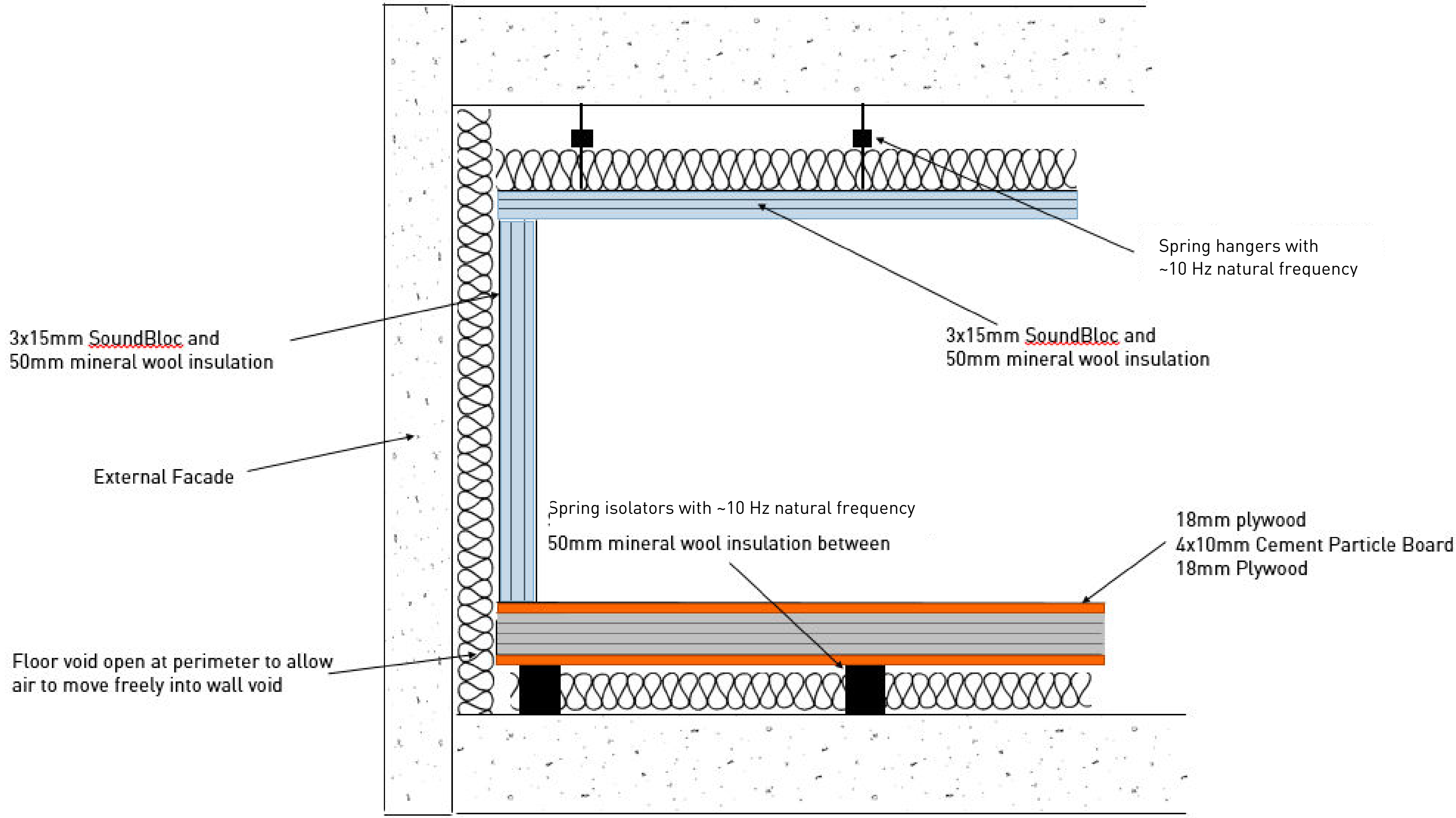
Positions V5-V8: 1st Floor Office

Positions V9-V11: 2nd Floor Office



Positions V12-V15: 3rd Floor Office





14-16 Betterton Street

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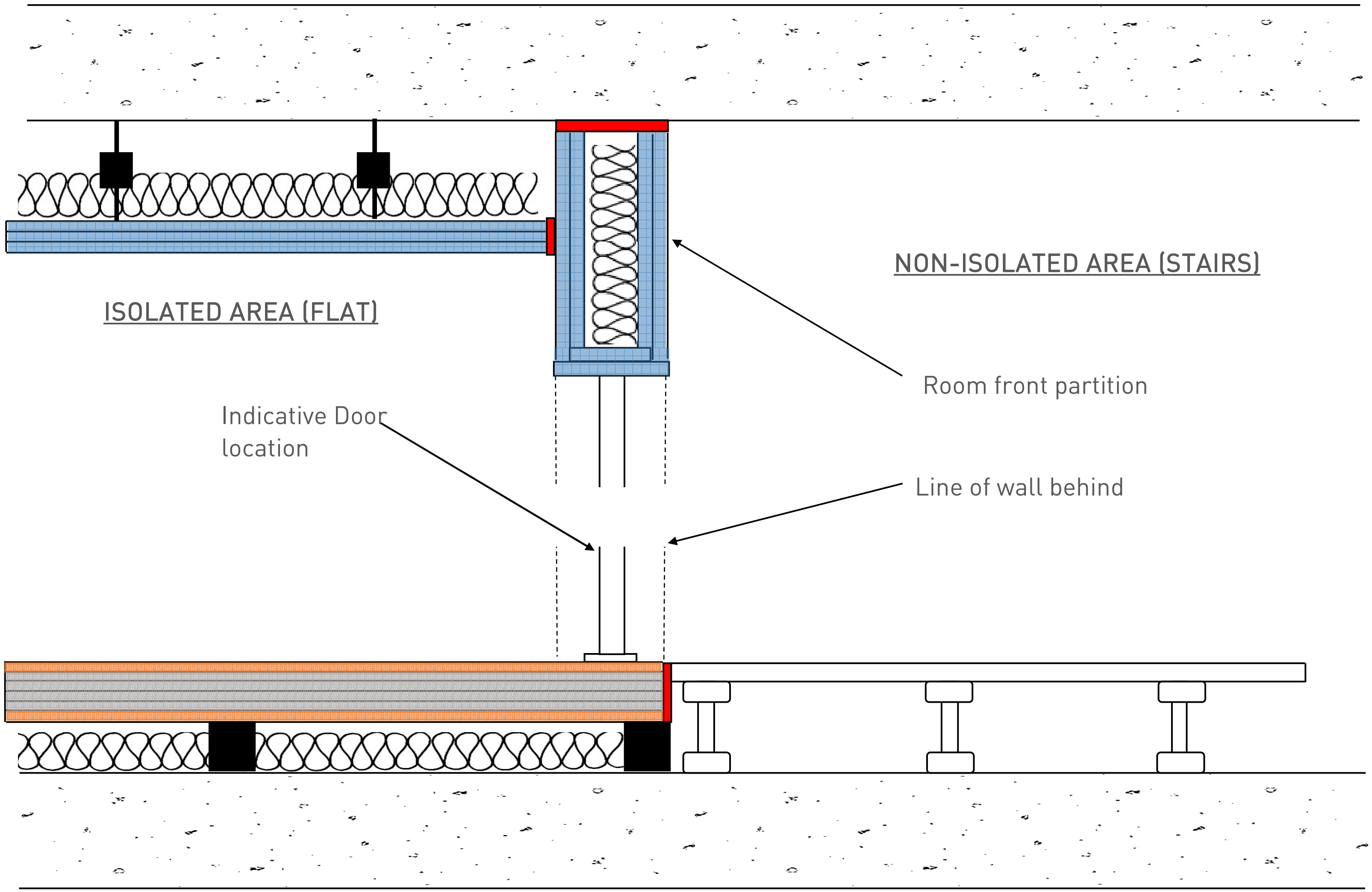
Indicative Box-in-box Detail

RBA ACOUSTICS



14-16 Betterton Street

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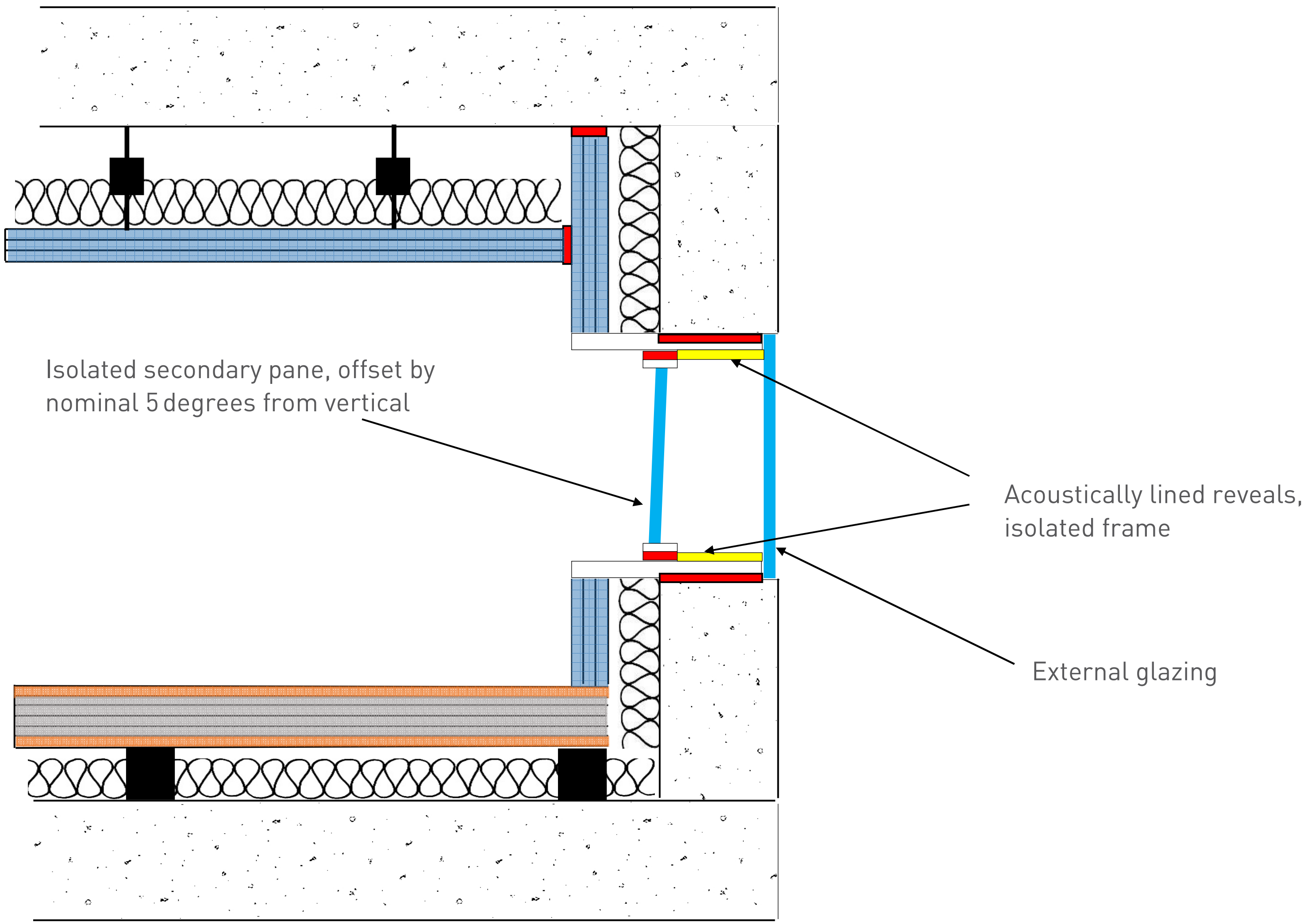
Indicative Door Detail – Isolated to Non-Isolated areas

RBA ACOUSTICS



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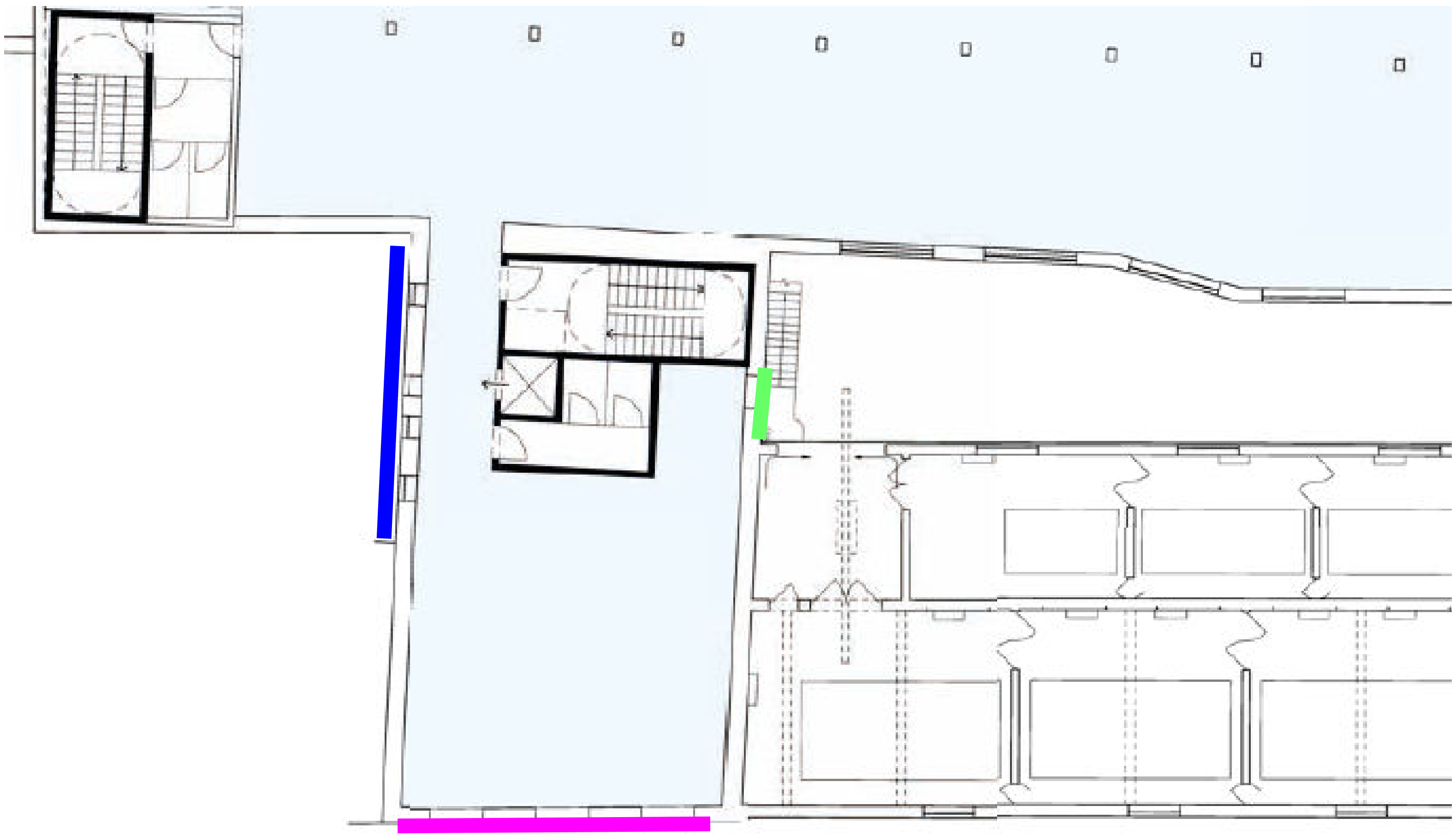
Indicative Window Detail

RBA ACOUSTICS



Key:

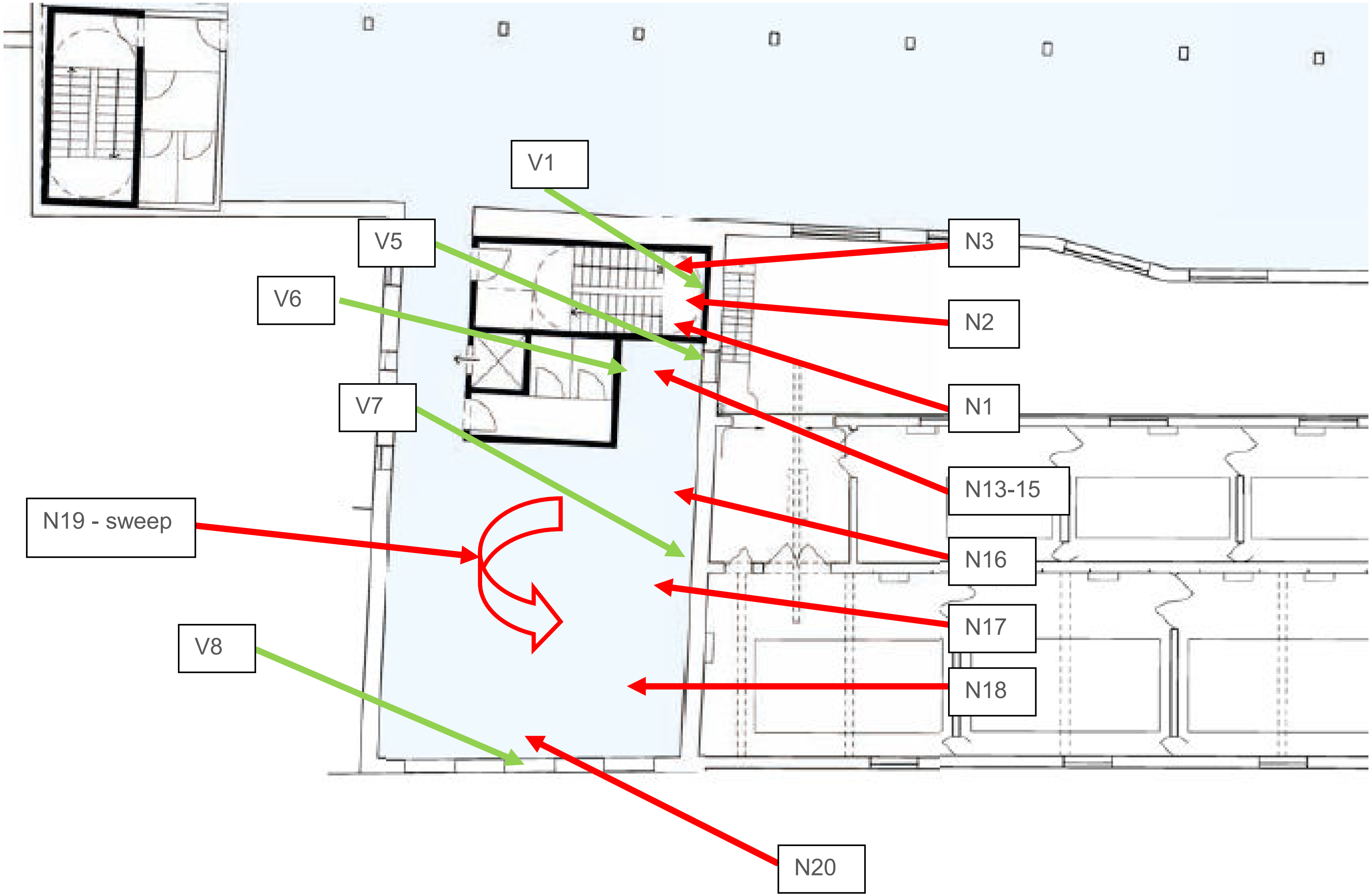
Zone 1:	
Zone 2:	
Zone 3:	

14-16 Betterton Street

Site Plan Indicating Façade Zones

7431/FZ1

RBA ACOUSTICS



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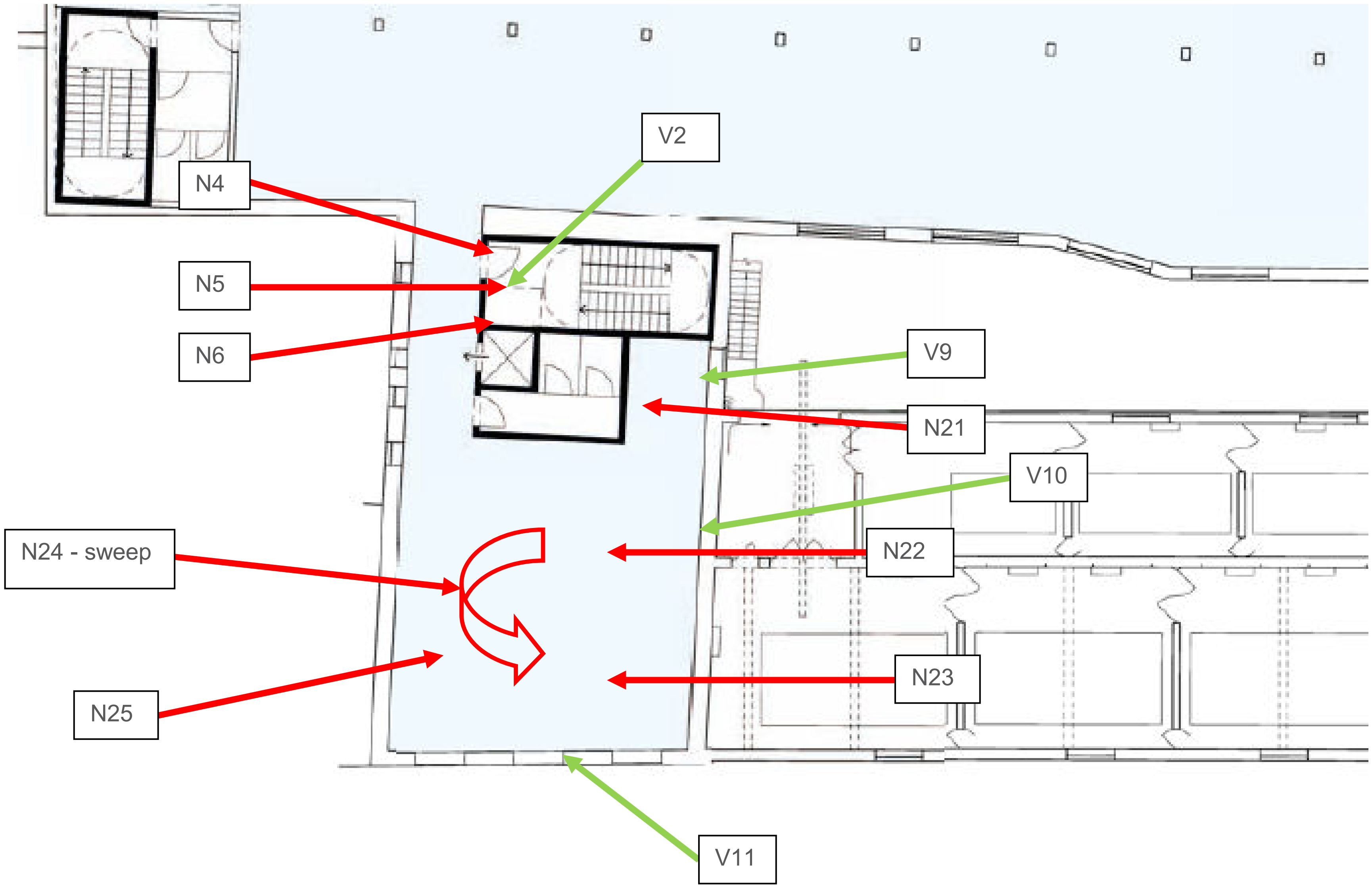
1ST Floor Plan Indicating Measurement Positions

RBA ACOUSTICS



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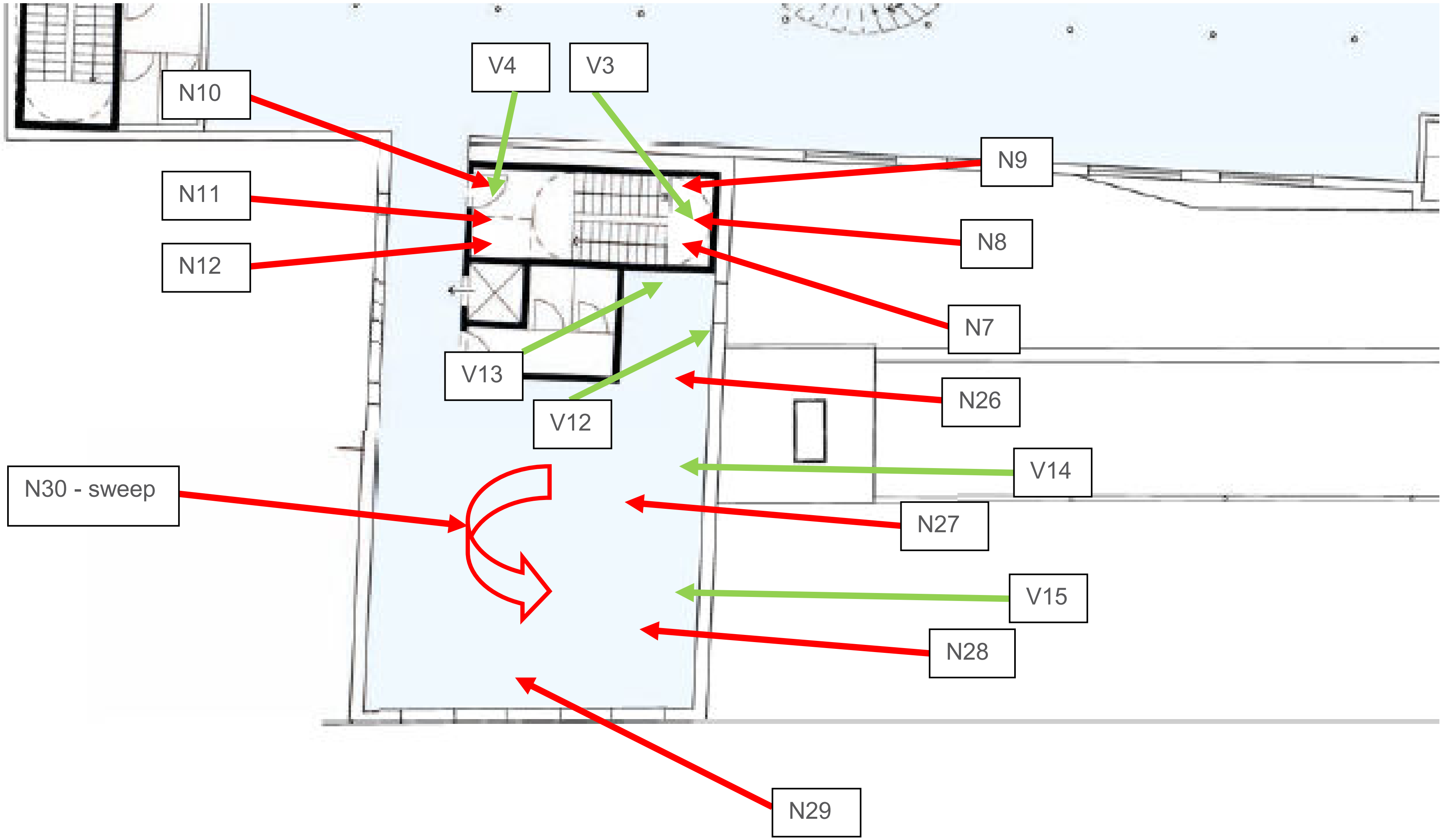
2nd Floor Plan Indicating Measurement Positions

RBA ACOUSTICS



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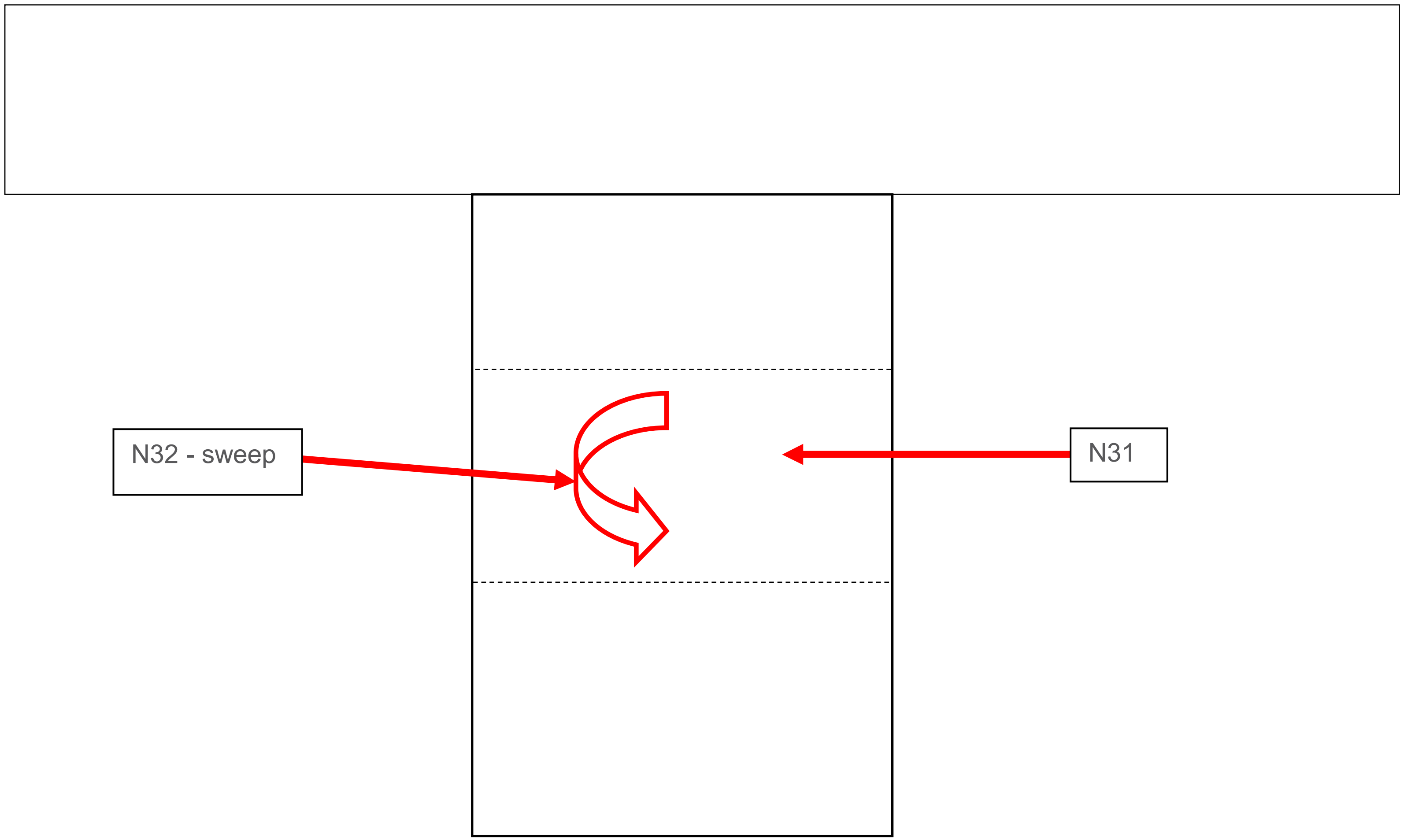
3rd Floor Plan Indicating Measurement Positions

RBA ACOUSTICS



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3rd Floor Mezzanine Plan Indicating Measurement Positions

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