

SANDY BROWN

Consultants in Acoustics, Noise & Vibration

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58-66 King Street, Manchester

Noise and vibration planning report

London, Manchester, Edinburgh, Birmingham, Belfast

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Summary

Sandy Brown has been commissioned by CogentBC to provide acoustic advice in relation to the proposed development at 58-66 King Street, Manchester.

An environmental noise and vibration survey have been carried out at the site. The noise survey was carried out between 22 January 2021 and 26 January 2021. The vibration survey was undertaken on 22 January 2021.

The representative background sound levels during the survey were $L_{A90,15min}$ 50 dB during the daytime and $L_{A90,15min}$ 49 dB at night.

Based on the requirements of the Manchester City Council 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} 45 dB during the daytime and L_{Aeq} 44 dB during the night.

The average ambient noise levels measured during the survey were $L_{Aeq,16h}$ 59 dB during the daytime and $L_{Aeq,8h}$ 54 dB at night.

A plant noise egress assessment has been undertaken. Based on the proposed plant items and the recommended acoustic louvres proposed to the perimeter of the plant area, it is expected that the daytime (07:00-23:00) and night-time (23:00-07:00) plant noise egress limits are capable of being met.

An initial assessment has been carried out to determine required acoustic performances for the facades and provide guidance on the ventilation strategy.

The sound insulation performance requirements for external windows range between $R'_w + C_{tr}$ 30 dB and $R'_w + C_{tr}$ 35 dB depending on the location of the facade.

Background ventilation and overheating ventilation is to be provided in the form of mechanical ventilation. Either new double glazing or secondary glazing will be required.

A Level 1 acoustics, ventilation and overheating assessment has been undertaken, the results of which indicate a Level 2 assessment should be carried. Whole house mechanical ventilation is to be provided within individual apartments in the form of MVHR systems. These systems will provide background ventilation and additional ventilative cooling during periods of overheating and there shall be no reliance on openable windows. Openable windows may be used during periods of purge ventilation (eg to remove cooking or paint smells).

Internal operational noise limits have been set for the proposed commercial units in order to ensure entertainment noise egress and transfer are adequately controlled.

The vibration assessment indicates that re-radiated noise and tactile vibration are expected to be below their respective criteria.

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1 Introduction

Sandy Brown has been commissioned by CogentBC to provide an assessment of noise and vibration in relation to the proposed development at 58-66 King Street, Manchester.

Environmental noise and vibration surveys have been carried out to establish:

- background sound levels around the site and by nearby noise sensitive premises
- ambient and maximum noise levels at the site
- vibration levels affecting the site.

The background sound levels measured during the survey are used as the basis for setting limits for noise emission from proposed building services plant. These limits are set in accordance with the requirements of the Manchester City Council.

Ambient and maximum noise levels are used to assess building envelope sound insulation requirements to achieve appropriate internal noise levels for residences. These follow standards set in accordance with Manchester City Council guidelines.

Vibration levels are used to assess the degree to which the proposed development will be affected by tactile vibration and re-radiated noise from the tram line running adjacent to the site along Cross Street.

This report provides details of the noise and vibration surveys, including measurement results, and provides recommendations.

2 Site description

2.1 The site and its surroundings

The site location in relation to its surroundings is shown in Figure 1 with the site highlighted in red. To the north of the site is King Street, to the east Cross Street, to the south is South King Street and to the east is Deansgate Road. The Manchester Metrolink tram line runs to the east of the site along Cross Street, between Manchester Victoria and St Peters Square.



Figure 1 Aerial view of site (courtesy of Google Earth Pro)

2.2 Adjacent premises

To the north of the site is 37, 49 and 51 King Street which are a mix of office and commercial premises. These are highlighted in pink within Figure 1.

To the east of the site is 50 King Street, which is also a mix of office and commercial premises. This is highlighted in yellow within Figure 1.

To the south of the site is St James's Square, which is office premises and highlighted in blue within Figure 1.

Directly to the west of the site is 56 King Street which is further commercial premises and highlighted in brown within Figure 1. Further to the west highlighted in green are a number of residential apartments located within 33 and 35 South King Street.

3 Development proposals

The proposed development comprises the redevelopment and conversion of three adjacent buildings that were previously used as offices to form residential apartments over four floors (first floor to fourth floor). One of the buildings, 62 King Street has Grade II listed status. The ground floor of each of the buildings comprises a commercial unit.

3.1 Hours of operation

The exact uses for the commercial units are yet to be confirmed as at this time they are currently vacant, however for the purpose of this assessment it is assumed they will be capable of operate during both the daytime (07:00-23:00) and night-time (23:00-07:00).

3.2 Potential noise sources

The potential noise sources associated with the scheme can be broadly divided into two categories:

- Building services plant
- Internal activity in commercial units.

The potential impact of these sources has been assessed and mitigation measures have been proposed to minimise impact on existing noise sensitive premises around the development.

4 Assessment criteria

4.1 NPPF and NPSE

The National Planning Policy Framework, February 2019 (NPPF) sets out the UK government's planning policies for England. It supersedes previous guidance notes such as PPG24. No specific noise criteria are set out in the NPPF, or in the Noise Policy Statement for England (NPSE) to which it refers.

The NPPF states:

'Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

- mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life.*
- identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.'*

and

'Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community

facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed.'

The NPSE states that its aims are as follows:

'Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- *Avoid significant adverse impacts on health and quality of life*
- *Mitigate and minimise adverse impacts on health and quality of life and*
- *Where possible, contribute to the improvement of health and quality of life.'*

As such, neither document sets out specific acoustic criteria for new residential developments, but they require consideration of the effect of existing noise on the new development and the effect of noise from the development on the surroundings.

4.2 Noise egress

4.2.1 Standard guidance

BS 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound* (BS 4142) provides a method for assessing noise from items such as building services plant against the existing background sound levels at the nearest noise sensitive premises.

BS 4142 suggests that if the noise level is 10 dB or more higher than the existing background sound level, it is likely to be an indication of a significant adverse impact. If the level is 5 dB above the existing background sound level, it is likely to be an indication of an adverse impact. If the level does not exceed the background level, it is an indication of having a low impact.

If the noise contains 'attention catching features' such as tones, bangs etc, a penalty, based on the type and impact of those features, is applied.

4.2.2 Local Authority criteria – Building services noise egress

Manchester City Council, GD03 Public protection information for developers, Section 3, sets out planning conditions in relation to noise egress from plant associated with developments:

'Before the development hereby approved is occupied, the building, together with any externally mounted ancillary equipment, shall be acoustically insulated in accordance with the scheme submitted to and approved in writing by the City Council as local planning authority in order to secure a reduction in the level of noise emanating from the site/property. Externally mounted ancillary plant, equipment and servicing shall be acoustically treated in accordance with a scheme designed so as to achieve a noise level of 5dB below the existing background (LA90) in each octave band at the nearest noise sensitive location.'

4.2.3 Local Authority criteria – Entertainment noise egress

Manchester City Council planning and noise technical guidance December 2015 also provides guidance on entertainment noise, which could result from the commercial units proposed as part of the development. This guidance states:

‘Music noise levels in the 63 Hz and 125 Hz octave centre frequency bands (L_{eq}) should be controlled so as not to exceed (in habitable rooms) 47 dB and 41 dB (L_{eq}), respectively’.

In addition to the above, for units which are structurally detached from other building uses should demonstrate that music noise from the proposal will not be ‘audible; in nearby residential properties, assuming that the residential properties in question have their windows open. The criterion is noted as:

‘Entertainment noise (L_{Aeq}) should be controlled to 10 dB below the background noise level (L_{A90}) without the entertainment noise present, in each octave band at the nearest noise sensitive location’

4.3 Noise ingress

4.3.1 Local Authority requirements

Manchester City Council stipulates the criteria provided in Table 1 with regards to internal noise in residential developments due to background ventilation.

Table 1 Manchester City Council internal noise criteria for residential developments

Internal space	Internal noise limit, L_{Aeq} (dB)	
	Daytime (07:00-23:00)	Night-time (23:00-07:00)
Living rooms	35	35
Bedrooms	35	30

It is also stipulated that individual noise events in bedrooms should not exceed L_{AFmax} 45 dB by more than 15 times.

It is understood from discussion with Manchester City Council that the above noise criteria do not apply during purge ventilation (ie, when windows are open to get rid of cooking /paint smells, etc) and that during rapid ventilation.

4.3.2 British Standard guidance

Guidance on acceptable internal noise levels in residential dwellings is given in BS 8233:2014 *Sound insulation and noise reduction for buildings*. The guidance limits are shown in Table 2.

These internal levels are based on annual average data and do not have to be achieved in all circumstances. It is normal to exclude occasional events, such as fireworks night or New Year's Eve.

Table 2 Internal noise criteria for sleeping/resting

Internal space	Indoor ambient noise level, L_{Aeq} (dB)	
	Daytime (07:00 – 23:00)	Night (23:00 – 07:00)
Living rooms	35	-
Dining room	40	-
Bedrooms	35	30 ^[1]

^[1] BS 8233 notes that individual noise events can cause sleep disturbance, and that a guideline value may be set depending on the character and number of events per night, although no specific limit is provided. For regular events, such as scheduled aircraft or passing trains, a guideline value may be set in terms of SEL or $L_{Amax,F}$. Sporadic noise events could require separate values.

The standard states that where development is considered necessary or desirable, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.

For external amenity areas, such as gardens and patios, the standard states:

'it is desirable that the external noise level does not exceed 50 dB $L_{Aeq,T}$ with an upper guideline value of 55 dB $L_{Aeq,T}$ which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.'

4.3.3 Acoustics, ventilation and overheating

Guidance on external noise levels from transport noise sources and the assessment of risk in an overheating condition is given in the Association of Noise Consultants *Acoustics Ventilation and Overheating, Residential Design Guide* (AVOG).

A Level 1 assessment comprises assessing the external free-field noise levels to guideline thresholds. External noise levels and the associated risk categories for a Level 1 assessment are adapted and summarised in Table 3, though consideration also has to be given the duration and frequency of any overheating periods.

Table 3 Guidance for Level 1 assessment of noise from transport sources relating to overheating condition

Risk category for Level 1 assessment	External free-field noise level	
	Daytime (07:00 – 23:00)	Night (23:00 – 07:00)
Negligible	$L_{Aeq} \leq 52$ dB	$L_{Aeq} \leq 47$ dB
Low	$L_{Aeq} > 52$ dB and $L_{Aeq} \leq 57$ dB	$L_{Aeq} > 47$ dB and $L_{Aeq} \leq 52$ dB
Medium	$L_{Aeq} > 57$ dB and $L_{Aeq} \leq 62$ dB	$L_{Aeq} > 52$ dB and $L_{Aeq} \leq 55$ dB
High	$L_{Aeq} > 62$ dB	$L_{Aeq} > 55$ dB

If a Level 1 assessment finds that the development falls into a 'Medium' or 'High' risk category a Level 2 assessment should be carried out, assessing the expected internal noise levels for an overheating condition and the associated risk of adverse effect. The Level 2 assessment would consider the following:

- Duration of period where additional ventilative cooling is required (to be assessed by others, typically part of a CIBSE TM59 assessment)
- How wide the external windows would need to be open to control overheating (to be assessed by others, typically part of a CIBSE TM59 assessment).

The guidance for suitable internal noise levels in order that noise ingress can be suitably controlled for an overheating condition are provided in AVOG. These are adapted and summarised in Table 4, though are not supposed to be taken as limits, rather guidelines to be assessed while also considering the adverse effect of any overheating (duration and severity).

The lowest observed affect level (LOAEL) and the significant observed affect level (SOAEL) for increased noise levels associated with controlling overheating are specific to each project as these depend on the magnitude of the increased internal noise levels and the duration for which they occur.

Table 4 Guidance for Level 2 assessment of noise from transport sources relating to overheating condition

Effect level	Internal noise level from transport sources		
	Daytime (07:00 – 23:00)	Night (23:00 – 07:00)	
LOAEL (noise can be heard, but does not cause any change in behaviour)	$L_{Aeq} \leq 35$ dB	$L_{Aeq} \leq 30$ dB	L_{AFmax} 45 dB not normally exceeded
SOAEL upper limit for longer overheating durations	$L_{Aeq} > 35$ dB and $L_{Aeq} \leq 40$ dB	$L_{Aeq} > 30$ dB and $L_{Aeq} \leq 35$ dB	-
SOAEL upper limit for shorter overheating durations	$L_{Aeq} > 40$ dB and $L_{Aeq} \leq 50$ dB	$L_{Aeq} > 35$ dB and $L_{Aeq} \leq 42$ dB	-
Exceeds SOAEL (noise causes a material change in behaviour)	$L_{Aeq} > 50$ dB	$L_{Aeq} > 42$ dB	L_{AFmax} 65 dB normally exceeded

The AVOG illustrates that there is a link between adverse effects, increasing internal ambient noise levels and the duration of exposure to noise for an overheating condition. These are indicated in Figure 2.

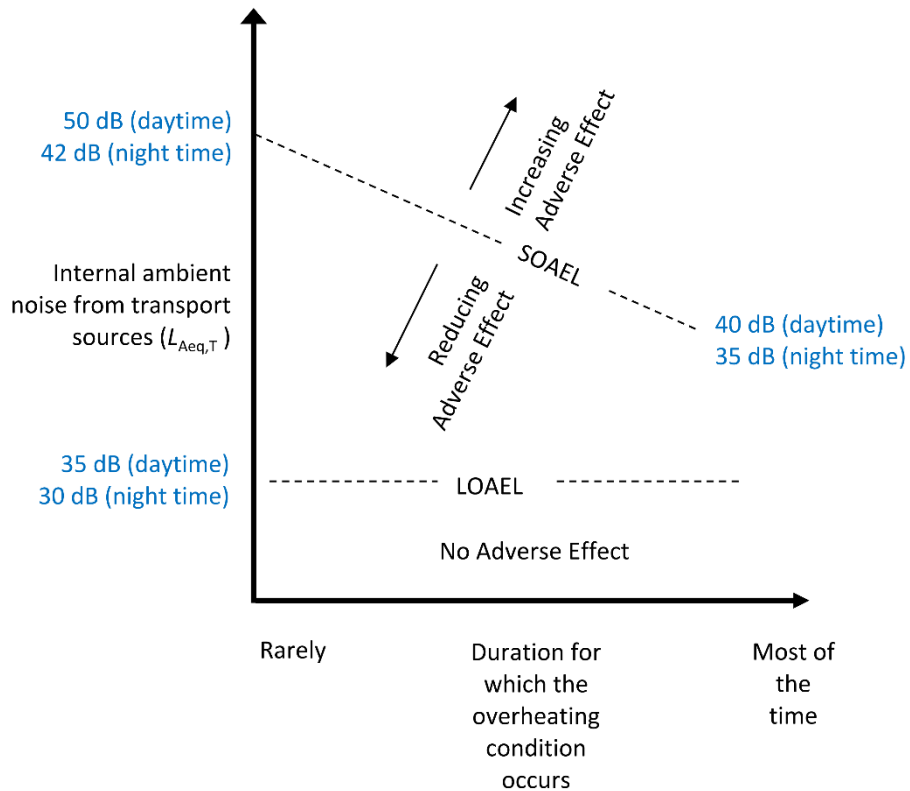


Figure 2 Internal ambient noise levels and increasing adverse effects for an overheating condition

When internal noise levels are above Significant Observed Adverse Effect Level (SOAEL), it is likely that there will be a high potential for an adverse outcome. These adverse outcomes will include:

- Material change in behaviour and/or attitude, eg avoiding certain activities during periods of intrusion
- Where there is no alternative ventilation, having to keep windows closed most of the time because of the noise
- Potential for sleep disturbance and difficulty in getting back to sleep
- Quality of life diminished.

As illustrated, the potential for adverse risk increases with the duration of exposure to noise, ie, a shorter exposure will result in a lower risk of adverse outcomes.

4.4 Tactile vibration criteria

4.4.1 Standard guidance

Tactile vibration is that which is perceived as mechanical motion. BS 6472-1:2008 *Guide to Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration Sources Other Than Blasting* 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.

The BS 6472-1:2008 assessment criteria are presented in Table 5.

Table 5 BS 6472-1: 2008 tactile vibration assessment criteria

VDV (m/s ^{1.75}) above which might result in various probabilities of adverse comment within residential buildings.			
Place	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Residential buildings 16 hr day	0.2 – 0.4	0.4 – 0.8	0.8 – 1.6
Residential building 8 hr night	0.1 – 0.2	0.2 – 0.4	0.4 – 0.8

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.

4.5 Re-radiated noise criteria

4.5.1 Standard guidance

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 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, and 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 L_{Amax} 40 dB.
- 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 L_{AFmax} 35 dB.

In all 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.

5 Survey method

5.1 Noise survey method

The survey included unattended and attended noise measurements.

5.1.1 Unattended measurements

Unattended noise monitoring was undertaken at the site over 5 days.

Details of the equipment used and the noise indices measured are provided in Appendix A.

The unattended measurements were taken over 15 minute periods between 13:20 on 22 January 2021 and 11:20 on 26 January 2021. The equipment was installed by Kane Mitchell and Jess Wright and collected by Kane Mitchell

The measurement position used during the survey is indicated in Figure 1, denoted by the letter 'L5'. A photograph showing the measurement location is provided in Figure 3.



Figure 3 Photograph showing the unattended measurement position 'L5'

This location was chosen to be reasonably representative of noise levels at the site and outside the nearest noise sensitive premises. The logger microphone was located out of a first floor window, approximately 1 m from the building facade.

5.1.2 *Attended measurements*

Attended sample measurements were taken by Kane Mitchell and Jess Wright at 4 locations around the site. These are indicated in Figure 1 as positions 'L1' to 'L4'.

The attended measurements were carried out on 22 January 2021 and 26 January 2021, over 5 minute periods.

At each position 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. Details of the equipment used and the noise indices measured are provided in Appendix A.

Dominant noise sources occurring during the measurements were noted.

5.2 Vibration survey method

Vibration measurements were taken at one location around the site in order to determine the vibration levels resulting from the passage of trams on the tram tracks adjacent to the site. The vibration measurement location is indicated in Figure 1 as position 'V1' with a green marker.

Measurement location 'V1' was within the building, in a room at level 1.

The measurement location 'V1' is shown within Figure 4.

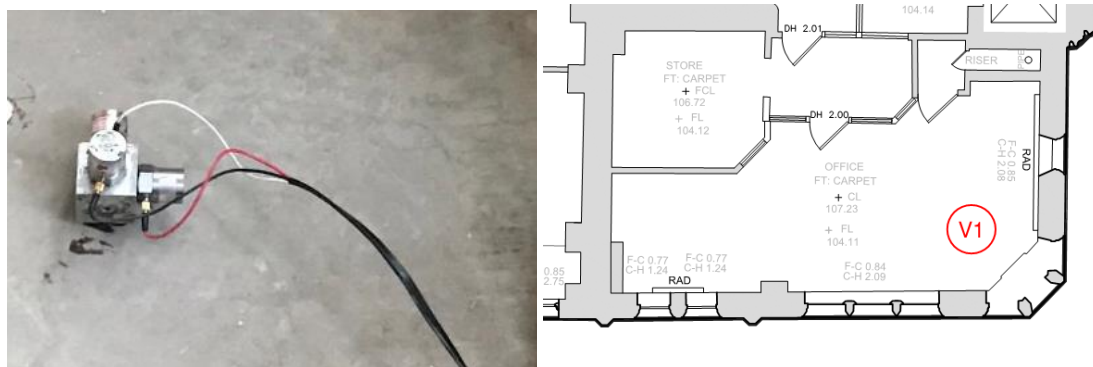


Figure 4 Vibration measurement location 'V1'

The measurements were taken on 22 January 2021 by Kane Mitchell between 15:20 and 16:30.

Vibration time histories were recorded using a tri-axial accelerometer and data recorder. The accelerometers were arranged on a mounting block that was connected to a ground-bearing concrete slab. A metal washer was fixed to the slab using a thin layer of epoxy adhesive, away from the boundaries of the room, with the mounting block attached to the washer.

The vibration measurements were conducted in three axes as follows:

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

Details of the equipment used and the noise indices measured are provided in Appendix A.

The vibration measurements taken at location are considered to be reasonably representative of the vibration levels to be experienced by the proposed residential premises.

5.3 Weather conditions

Weather conditions during the survey are described in Appendix A.

6 Measurement results

6.1 Observations

6.1.1 Noise

The dominant noise sources observed at the site during the survey were from traffic and trams passing along Cross Street.

Less significant noise sources included construction noise, building services noise, vehicles along King Street and South King Street, pedestrians and bird song.

6.1.2 Vibration

Subjectively there was no perceptual vibration at the measurement location. The occurrence of tram events was determined by maintaining a line of sight to the tram line.

6.2 Impact of Covid-19 pandemic on the surrounding noise climate

The noise levels measured at and around the site have been compared to historical noise data for other sites within close proximity in order to assess the impact of Covid-19 on the surrounding noise climate.

The historical noise data reviewed suggests that the noise levels measured are representative of the noise climate around the site prior to the pandemic and related lockdowns, therefore no corrections to the measured noise levels corrections have been made.

The historical noise data was measured during an environmental noise survey for 51 King Street, full details of which can be found in Sandy Brown report 15130-R02-C *Environmental noise survey report* dated 30 April 2015, MCC planning reference 108781/FO/2015/C1.

The results of this survey were average ambient noise levels in the region of $L_{Aeq,16h}$ 59 dB during the daytime and $L_{Aeq,8h}$ 53 dB during the night-time.

The representative background noise levels measured were $L_{A90,15min}$ 52 dB during the daytime and $L_{A90,15min}$ 45 dB during the night.

These noise levels are considered to be comparable to those measured at this site as provided in Section 6.3.

6.3 Noise measurement results

6.3.1 Unattended measurement results

A graph showing the results of the unattended measurements is provided in Appendix B.

Day and night-time ambient noise levels measured during the unattended survey are presented in Table 6.

These measurements are considered to be facade measurements.

Table 6 Ambient noise levels measured during the unattended survey

Date	Daytime (07:00 – 23:00) $L_{Aeq,16h}$ (dB)	Night (23:00 – 07:00) $L_{Aeq,8h}$ (dB)
Friday 22 Jan 2021	59 ^[1]	55
Saturday 23 Jan 2021	59	52
Sunday 24 Jan 2021	57	54
Monday 25 Jan 2021	60	55
Tuesday 26 Jan 2021	61 ^[1]	-
Average	59	54

^[1] Measurement not made over full period due to monitoring start and end time (the measurement on 22 January 2021 was over 10 hours, and on 26 January 2021 over 4 hours); not included in the average.

Analysis of night-time maximum noise levels indicates that the night-time maximum noise level not normally exceeded 10 times a night is L_{AFmax} 73 dB.

In line with BS 4142:2014+A1:2019, representative background sound levels have been determined using statistical analysis of the continuous measurements.

Daytime and night-time statistical analysis of representative values for the site are given in Figure 5 and Figure 6.

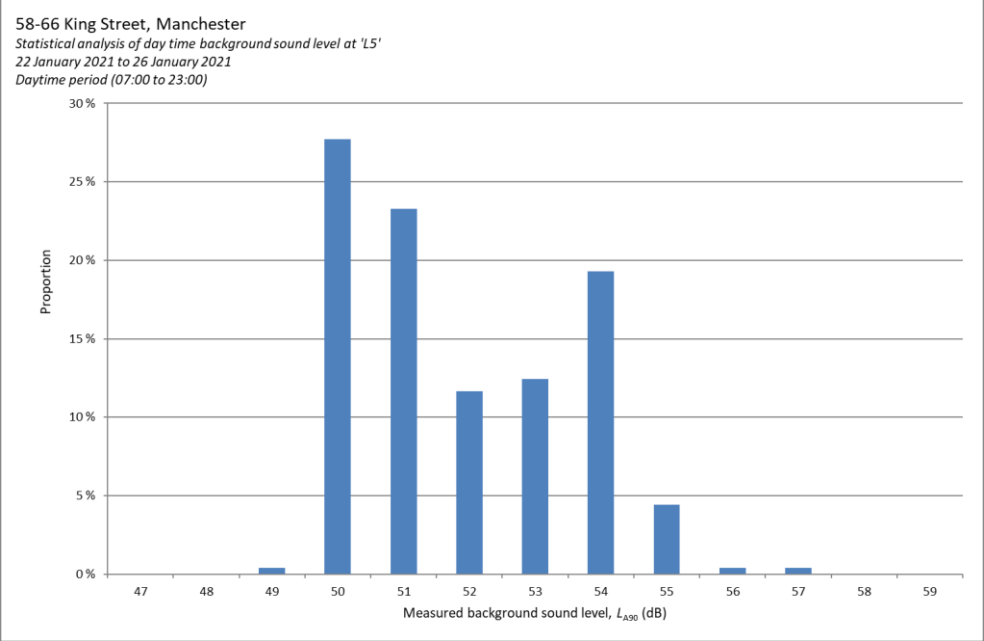


Figure 5 Daytime statistical analysis of background sound levels at location 'L5'

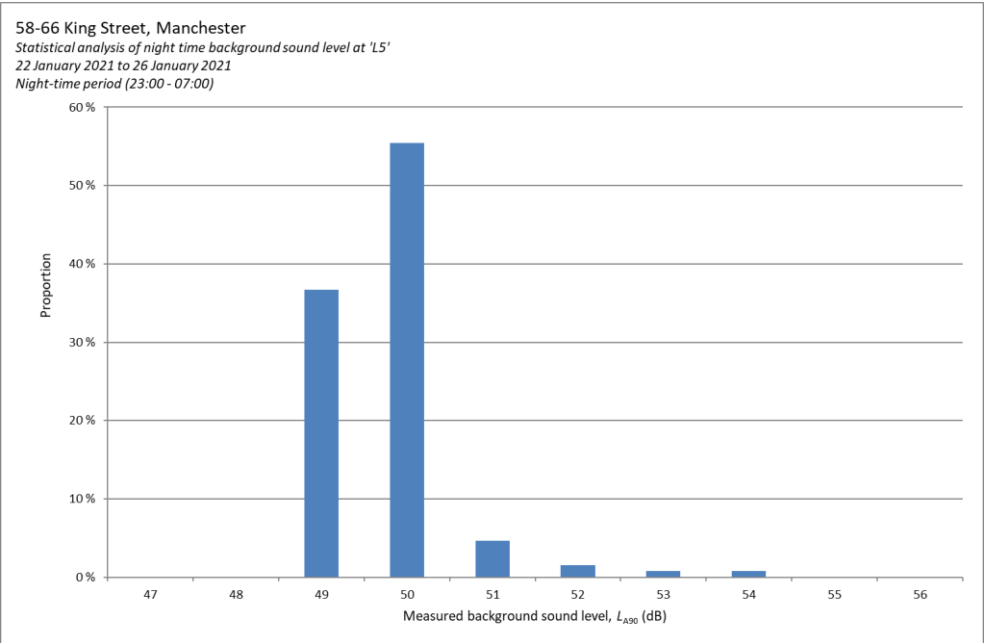


Figure 6 Night-time statistical analysis of background sound levels at location 'L5'

From this analysis, the representative background sound levels measured during the survey were $L_{A90,15min}$ 50 dB during the daytime and $L_{A90,15min}$ 49 dB at night.

Representative background octave band spectra are provided in Table 7 for daytime and night. These are required to set operational noise limits as discussion Section 9.1.1.

Table 7 Representative background sound pressure spectra

Period	Sound pressure level, L_{eq} (dB)						
	Octave-band centre frequency (Hz)						
	63	125	250	500	1000	2000	4000
Daytime (07:00 – 23:00)	59	54	47	48	45	40	33
Night-time (23:00 – 07:00)	58	53	45	47	43	39	32

6.3.2 Attended measurement results

Noise levels and key sources recorded during the attended measurements are summarised in Table 8. These measurements were free field measurements.

Table 8 Noise levels and key noise sources from attended measurements

Position	Start time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$	
<i>Measurements undertaken on 22 January 2020</i>					
1	14:20	66	83	56	Dominant noise source was traffic along Cross Street. Other noise sources include building services, construction noise, passing vehicles and trams
1	14:25	67	85	57	
1	14:30	64	85	56	
2	15:05	61	75	59	Dominant noise source was traffic along Cross Street. Other noise sources include building services, construction noise, passing vehicles and trams
2	15:10	62	72	59	
2	15:15	61	71	59	

Position	Start time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$	
3	14:20	58	69	56	Dominant noise source was traffic along Cross Street. Other noise sources include building services noise, construction noise, pedestrians and trams
3	14:25	59	76	56	
3	14:30	60	73	55	
4	14:50	59	71	54	Dominant noise source was traffic along Cross Street. Other noise sources include building services noise, construction noise, pedestrians and trams
4	14:55	62	75	54	
4	15:00	60	72	54	
<i>Measurements undertaken on 26 January 2020</i>					
1	09:50	66	92	57	Dominant noise source was traffic along Cross Street. Other noise sources include building services, construction noise, passing vehicles and trams
1	09:55	64	87	58	
1	10:00	64	86	57	
2	10:05	64	89	56	Dominant noise source was traffic along Cross Street. Other noise sources include building services, construction noise, passing vehicles and trams
2	10:10	58	68	56	
2	10:15	60	72	56	

Position	Start time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$	
3	09:20	60	71	56	Dominant noise source was traffic along Cross Street. Other noise sources include building services noise, construction noise, pedestrians and trams
3	09:25	59	71	56	
3	09:30	59	72	56	
4	09:35	63	89	57	Dominant noise source was traffic along Cross Street. Other noise sources include building services noise, construction noise, pedestrians and trams
4	09:40	61	74	56	
4	09:45	63	75	55	

6.4 Vibration measurement results

VDVs measured at location 'V1' are presented in Table 9.

The maximum VDV_z measured for each of the directions are highlighted in red.

Measurements of RMS acceleration are presented in Appendix C.

Table 9 VDV_z measured at location 'V1'

Start time	Number of events	VDV (m/s ^{1.75})		
		X	Y	Z
15:35	1	0.0003	0.0002	0.0042
15:40	1	0.0003	0.0003	0.0041
15:43	1	0.0002	0.0003	0.0062
15:47	1	0.0004	0.0003	0.0050
15:50	1	0.0004	0.0004	0.0035

7 Plant noise egress

7.1 Plant noise egress limits

Based on the above criteria and the measurement results, the cumulative noise level from the operation of all new plant should not exceed the limits set out in Table 10.

The limits apply at 1 m from the worst affected windows of the nearest noise sensitive premises and are presented as facade levels. In this case these limits would apply at the noise sensitive receptors identified in Section 2.2.

Table 10 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, $L_{Aeq,15min}$ (dB)
Daytime (07:00 – 23:00)	45
Night-time (23:00 – 07:00)	44

[1] The limits set out in Table 10 do not include any attention catching features. The penalty corrections for attention catching features may be significant and will need to be considered as the building services design progresses. This is discussed in Appendix D.

7.2 Assessment

7.2.1 Proposed plant items

24 VRF units are proposed to the rooftop plant area. The locations of these units are shown in Figure 7 with the units highlighted in blue.

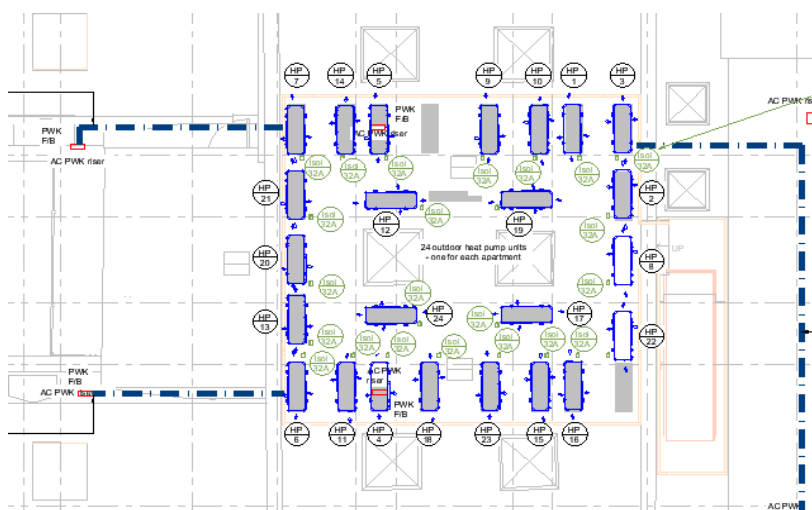


Figure 7 Locations of the proposed rooftop plant items

Table 11 sets out the sound pressure data provided for the VRF units.

Table 11 Provided rooftop plant data used for assessment

Unit ref.	Location	Sound pressure level at 1 m, L_{eq} (dB), Octave-band centre frequency (Hz)							
		63	125	250	500	1000	2000	4000	8000
3MXM-N VRF (Small)	Flats 1, 2, 3, 8, 9, 10, 16, 17.	49	49	47	45	41	36	28	21
3MXM-N VRF (Large)	Flats 4-7, 11- 15, 18-24	51	51	49	47	43	38	30	23

7.2.2 Proposed screening

To control noise emissions from the VRF units, acoustic louvred screening is proposed to the perimeter of the plant area. The location of this screening is shown in Figure 8 highlighted in red.

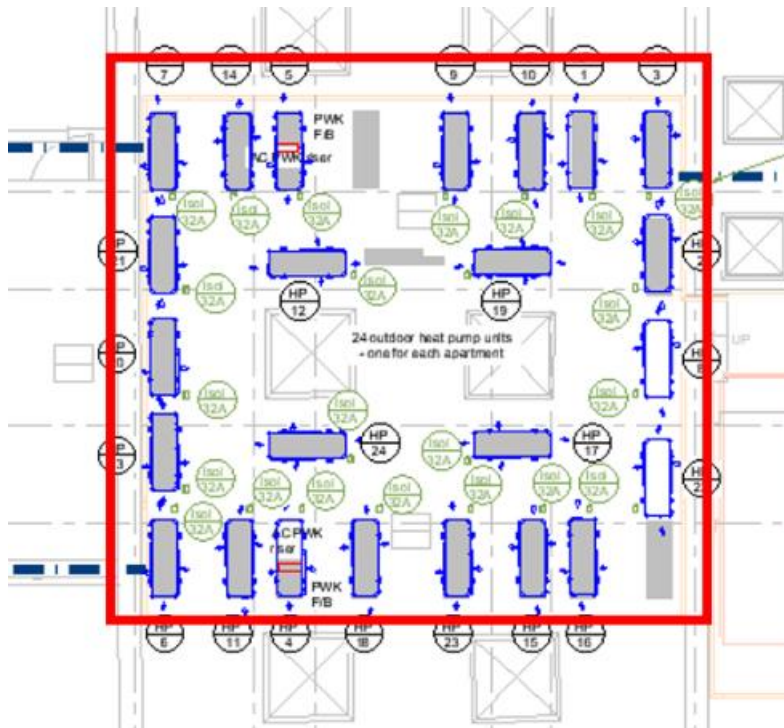


Figure 8 Location of acoustic louvre screening

The screening shall be a minimum 1 m tall in relation of the plant deck and will achieve the minimum insertion losses set out in Table 12. The airflow requirements of the proposed plant items would need to be checked to ensure the louvres are positioned a suitable distance away from the units. The louvres would need to be selected so that they do not cause levels of regenerated noise that would increase the resultant noise level.

Table 12 Minimum acoustic louvre insertion loss.

	Octave-band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Minimum insertion loss (dB)	5	4	5	5	8	12	12	10

7.2.3 Results of assessment

When considering the proposed plant items as per Section 7.2.1 and the proposed mitigation as per Section 7.2.2, it is expected that the daytime (07:00-23:00) and night-time (23:00-07:00) plant noise egress limits as per Table 10 will be achieved.

Plant noise egress calculations are provided within Appendix E.

8 Facade sound insulation – noise ingress

This section describes an assessment of facade sound insulation to control noise ingress. The required facade specification largely depends on the external noise levels and the internal noise criteria.

The following assessment is based on achieving the internal noise levels recommended in BS 8233:2014 and by the Manchester City Council, which are set out in Section 4.2.2.

8.1 External noise levels

The facade zones considered within the assessment are shown in Figure 9.



Figure 9 Facade zones

The external ambient noise levels for the various facade zones are provided in Table 13.

These are based on the attended and unattended measurements undertaken at and around the site. Noise levels are expected to be reasonably consistent across Levels 1-4.

Noise levels at facade zone C, overlooking south King Street, were typically in the region of 3 dB louder than those measured at facade zone A. This is due to King Street being pedestrianised, whilst South King Street is still a through road.

During the night-time, it is expected that there will be a significantly reduced level of traffic along Cross Street and South King Street, and so the noise levels measured at unattended measurement position 'L5' are considered representative for night-time periods for all facade zones.

The maximum noise levels measured at position 'L5' have been considered representative for all facade zones, which is that the night-time maximum noise level not normally exceeded 10 times a night is L_{AFmax} 73 dB.

Table 13 External facade noise levels

Facade zone		Daytime (07:00 – 23:00) ambient noise level, L_{Aeq} (dB)	Night-time (23:00 – 07:00) ambient noise level, L_{Aeq} (dB)	L_{AFmax} not normally exceeded at night (dB)
A		59	54	73
B		59	54	73
C		62	54	73

8.2 Facade sound insulation

8.2.1 Overall facade sound insulation

Minimum facade sound insulation requirements for the facades, under the background ventilation condition, are given in Table 14. These have been determined to achieve the internal noise criteria for bedrooms and living areas as per Table 1 using predicted external noise levels at the facades.

At this site, the facade performance requirements are driven by the night-time maximum noise levels. The facade specification has been determined to ensure that $L_{AFmax\ 15\ min}$ criteria is exceeded on no more than 10 occasions based on the worst affected night during the survey.

Table 14 Facade sound insulation performance requirements

Facade zone		Minimum overall sound insulation performance, $R'_w + C_{tr}$ (dB)	
		Living rooms	Bedrooms
A		30	35 ^[1]
B		30	35
C		33	35

^[1] Bedrooms are not currently proposed along façade zone A, however sound insulation performance criteria has been provided based on the bedroom layouts as per facade zone C for completeness.

8.2.2 External window sound insulation

Calculations have been undertaken to assess the sound insulation performance requirements of the windows to living rooms and bedrooms in order to achieve the internal noise criteria summarised in Table 1.

These requirements are based on the glazed areas currently shown and are on the basis that the solid elements of the facade achieve a sound insulation performance at least 10 dB greater

than that of the windows, which is expected given the constructions of the solid facade elements. The window sound insulation performance requirements are set out in Table 15.

Table 15 Minimum window sound insulation performance requirements

Facade zone		Minimum window sound insulation performance, $R'_w + C_{tr}$ (dB)	
		Living rooms	Bedrooms
A		28	32 ^[1]
B		28	32
C		30	32

^[1] Bedrooms are not currently proposed along facade zone A, however a sound insulation performance requirement has been provided based on the bedroom layouts as per facade zone C for completeness.

8.3 Guidance on facade glazing

The existing external windows typically comprise of single glazing in timber frames, with some of the windows being sash windows. The existing windows would not be capable of achieving the sound insulation performances set out in Table 15. As such, one of the two options are to be provided to the external windows across the site:

1. Replace the windows with new frames and glazing or
2. Make the existing windows good and then provide secondary glazing.

These options are discussed in more detail within the following sections.

Table 16 sets out examples of glazing configurations that could achieve the required sound insulation performances as per Table 15. It would need to be ensured that new framing systems are capable of achieving a sound insulation performance equivalent to that of the glazing as a minimum.

Table 16 Example glazing configurations

Glazing sound insulation, $R'_w + C_{tr}$ (dB)	Example glazing configuration
28-29	6.8 mm acoustic laminate/16 mm cavity/6 mm glass
30-32	8.8 mm acoustic laminate /16 mm cavity/6 mm glass
33-35	8.8 mm acoustic laminate/16 mm cavity/10 mm glass

Secondary glazing could be provided to achieve the sound insulation performances set out in Table 15 in conjunction with the existing windows. The existing windows would need to be made good in this scenario. This would involve ensuring that the existing frames are well sealed, all seals are functioning correctly and any glazing that is cracked is replaced.

Example secondary glazing configurations are provided in Table 17.

Table 17 Example secondary glazing configurations

Glazing sound insulation, $R'_w + C_{tr}$ (dB)	Example glazing configuration
28-29	Existing 6 mm glazing/50 mm cavity with sound absorbent reveals/6 mm secondary glazing
30-32	Existing 6 mm glazing/50 mm cavity with sound absorbent reveals/6 mm secondary glazing
33-35	Existing 6 mm glazing/100 mm cavity with sound absorbent reveals/6 mm secondary glazing

It would also need to be ensured that the secondary glazing system can be properly cleaned and maintained.

8.4 Guidance on ventilation strategy

Background ventilation and overheating ventilation is to be provided in the form of mechanical ventilation via MVHR units, and there will be no reliance on openable windows.

Openable windows may be used during periods of purge ventilation e.g. to remove cooking or paint smells.

8.5 Acoustics, ventilation and overheating assessment

8.5.1 Level 1 assessment

A Level 1 assessment of noise ingress during an overheating condition has been carried out in line with Association of Noise Consultants *Acoustics Ventilation and Overheating, residential Design Guide*.

The Level 1 assessment indicates that the proposed development falls into the medium risk category and therefore a Level 2 assessment is required.

For a more detailed Level 2 assessment, it will need to consider the following:

- Duration of period where additional ventilative cooling is required (to be assessed by others, typically part of a CIBSE TM59 assessment)

- How wide the external windows would need to be open to control overheating (to be assessed by others, typically part of a CIBSE TM59 assessment)
- Design, extent and construction of attenuated passive ventilation.

8.5.2 Level 2 assessment

Background ventilation and overheating ventilation is to be provided in the form of mechanical ventilation.

Whole house mechanical ventilation is to be provided within individual apartments in the form of MVHR systems. These systems will provide background ventilation and additional ventilative cooling during periods of overheating and there shall be no reliance on openable windows. Openable windows may be used during periods of purge ventilation (eg, to remove cooking or paint smells). These periods are expected to be short in duration and infrequent and so noise ingress is not expected to have an adverse effect on occupants of the apartments when this occurs.

As per Figure 3-5 of *Acoustics, ventilation and overheating residential design guide Version 1.1*, indoor ambient noise levels from mechanical services should be in the region of the following during overheating conditions:

- Bedrooms - L_{Aeq} 30 ($\pm$ 5) dB
- Living rooms - L_{Aeq} 35 ($\pm$ 5) dB

The above limits would be in line with the relaxed criteria typically permitted by MCC during periods of purge ventilation as discussed within Section 4.3.1.

9 Operational noise limits

9.1.1 Operational noise egress limits

The cumulative noise level resulting from amplified sound egress at 1 m from the most affected windows of the nearest noise sensitive premises should not exceed 10 dB below the existing background sound level in octave bands. These limits are set out in Table 18.

Table 18 Maximum operational noise limits at 1 m from noise sensitive premises

Period	Maximum operational noise limits at 1 m from noise sensitive premises, L_{eq} (dB) Octave-band centre frequency (Hz)							L_{Aeq} (dB)
	63	125	250	500	1000	2000	4000	
Daytime (07:00 – 23:00)	49	44	37	38	35	30	23	40
Night-time (23:00 – 07:00)	48	43	35	37	33	29	22	38

9.1.2 Noise sensitive premises

The nearest noise sensitive premises are the adjacent office premises at 37, 49 and 51 King, approximately 10 m to the north of from GF commercial units and 50 King Street approximately 5 m to the east of the eastern commercial unit.

9.1.3 Operational noise limits in commercial units

The maximum operational noise levels (L_{eq}) from amplified sound within the proposed commercial unit are set out in Table 19.

These are based on the following:

- Meeting the daytime noise egress criteria set out in Section 4.2.3
- An assumed minimum overall facade sound insulation performance of $R'_w + C_{tr}$ 28 dB which is considered a reasonable worst-case scenario
- Meeting the noise transfer criteria for the residential apartments above set out in Section 4.2.3
- A minimum first floor sound insulation performance of $D_{nT,w} + C_{tr}$ 50 dB, this will require enhancement works to the first floor construction (see Section X).

The limits are provided for guidance only as in practice, there will be some variation in background noise levels within the office space. The exact amplified noise limits should be determined in-situ along with setting of electronic limiters. These limits would typically be included in a tenant lease agreement in order to control noise egress and noise transfer.

Table 19 Guideline maximum operational noise limits in commercial units

	Octave-band centre frequency (Hz)							L_{Aeq} (dB)
	63	125	250	500	1000	2000	4000	
Guideline maximum operational noise limits in one of the ground floor commercial units, L_{eq} (dB)	76	74	68	68	68	64	62	72

The above limits would be suitable for low level amplified background music. The limits are driven by noise transfer to the residential dwellings above.

The existing units are understood to be occupied by a travel agent and a nail bar. These uses would be expected to comply with the operational noise limits as per Table 19.

9.1.4 First floor enhancement works

It is proposed to enhancement first floor construction to achieve a minimum sound insulation performance of $D_{nT,w} + C_{tr}$ 50 dB.

It is proposed to enhance the first floor construction between the ground floor commercial units and first floor residential apartments using a floating timber floor, comprising of 20 mm screedboard bonded to a resilient layer.

The existing floor joists and ceilings within the commercial units are to be retained.

If noise levels higher than those noted above were desirable, additional enhancement works would be required in order to ensure that the Manchester City Council criteria are still met. Typical enhancement works would be expected to include:

- An enhanced floor / ceiling construction with flanking pathways suitably controlled
- Enhancements to external glazing
- Enhancements to the non-glazed elements of the facade
- Lobbied external doors.

10 Vibration assessment

10.1 Tactile vibration

BS 6472 states that the assessment should be based on the axis along which the highest VDV is measured. At measurement location 'V1', the highest VDV was measured on the Z axis.

Published timetables indicate that approximately between 6 and 12 trams pass the site per hour during the day. This will result in approximately 168 trams passing on the tracks between 07:00 – 23:00. At night, between 23:00 – 07:00, the number of trams operating along this line is expected to be approximately 12 trams.

Based on the maximum vibration values from Table 9 and on the number of trams passing on the tracks between 07:00 – 23:00 and 23:00 – 07:00, the equivalent VDV over a 16 hour day and an 8 hour night are given in Table 20.

Table 20 Equivalent vibration dose values

Location	Maximum VDV measured ($\text{m/s}^{1.75}$)	Equivalent VDV ($\text{m/s}^{1.75}$)	
		Daytime (07:00 – 23:00)	Night-time (23:00 – 07:00)
V1	0.0062	0.07	0.03

These predicted equivalent VDV, during the daytime and night periods are lower than the thresholds of the 'low probability of adverse comment' categories in Table 5.

The measured vibration levels were below the lowest BS 6472 threshold, and a significant increase in the number of trams would be required for the threshold to be exceeded. Based on this, tactile vibration due to trams is unlikely to be problematic for this development.

10.2 Re-radiated noise

Re-radiated noise within the proposed development was predicted using an empirical formula described in the ANC guidelines.

Of the tram passes captured during the survey period, all the predicted levels of re-radiated noise were in the region of L_{AFmax} 28-30 dB which is lower than the criteria discussed in Section 4.5.

On this basis, re-radiated noise in the proposed residences is unlikely to result in adverse comment. The predicted values are for worst-case first floor conditions. Noise levels from this source are expected to be lower at upper floor levels and areas stepped further back from the tram line.

11 Conclusion

The representative background sound levels were $L_{A90,15min}$ 50 dB during the day, and $L_{A90,15min}$ 49 dB during the night.

Based on the requirements of Manchester City Council, the relevant plant noise limits at the worst affected existing noise sensitive premises are L_{Aeq} 45 dB during the day, and L_{Aeq} 44 dB during the night. These limits are cumulative and apply with all plant operating under normal conditions.

A plant noise egress assessment has been undertaken. Based on the proposed plant items and the acoustic louvres proposed to the perimeter of the plant area, it is expected that the daytime (07:00-23:00) and night-time (23:00-07:00) plant noise egress criteria will be complied with.

The sound insulation performance requirements for external windows range between R'_w+C_{tr} 30 dB and R'_w+C_{tr} 35 dB depending on the location of the facade.

Background ventilation and overheating ventilation is to be provided in the form of mechanical ventilation. Either new double glazing or secondary glazing will be required.

A Level 1 acoustics, ventilation and overheating assessment has been undertaken, the results of which indicate a Level 2 assessment should be carried. Whole house mechanical ventilation is to be provided within individual apartments in the form of MVHR systems. These systems will provide background ventilation and additional ventilative cooling during periods of overheating and there shall be no reliance on openable windows. Openable windows may be used during periods of purge ventilation (eg to remove cooking or paint smells).

Internal noise limits have been set for the proposed commercial unit in order to ensure entertainment noise egress and transfer are adequately controlled.

Assessments of tactile vibration and re-radiated noise indicate these are unlikely to be problematic for the proposed development.

Appendix A

Survey details

Equipment

The unattended measurements were taken using a Rion NL52 sound level meter and the attended measurements were taken using a Rion NL52 and BK 2250 sound level meter.

The VDV, 1/3 octave band RMS acceleration and tri-axial acceleration measurements were carried out using a Rion DA20 data recorder and Rion PV-87 accelerometers.

Calibration details for the equipment used during the survey are provided in Table A1.

Table A1 Equipment calibration data

Equipment description	Type/serial number	Manufacturer	Calibration expiry	Calibration certification number
Sound level meter	2250/3011964	Brüel & Kjær	4 Sep 21	UCRT19/1970, UTRC19/1976
Microphone	4189/3100176	Brüel & Kjær	4 Sep 21	UCRT19/1970, UTRC19/1976
Pre-amp	ZC0032/26376	Brüel & Kjær	4 Sep 21	UCRT19/1970, UTRC19/1976
Calibrator	4231/3019123	Brüel & Kjær	3 Sep 21	UCRT19/1969
Sound level meter	NL-52/00932326	Rion	13 Mar 21	TCRT19/1179
Microphone	UC-59/05549	Rion	13 Mar 21	TCRT19/1179
Pre-amp	NH-25/32354	Rion	13 Mar 21	TCRT19/1179
Calibrator	NC-74/34125432	Rion	13 Mar 21	TCRT19/1178
Sound level meter	NL-52/01143564	Rion	15 Dec 22	TCRT20/1738
Microphone	UC-59/10153	Rion	15 Dec 22	TCRT20/1738
Pre-amp	NH-25/43581	Rion	15 Dec 22	TCRT20/1738
Calibrator	NC-74/34257023	Rion	14 Dec 22	TCRT20/1736
Data Recorder	DA-20/10870889	Rion	11 Sep 21	TCRT19/1712
Accelerometer	PV-87/33827	Rion	10 Sep 21	TCRT19/1708
Accelerometer	PV-87/74274	Rion	9 Dec 21	TCRT19/1707

Equipment description	Type/serial number	Manufacturer	Calibration expiry	Calibration certification number
Accelerometer	PV-87/33829	Rion	9 Sep 21	TCRT19/1706
Vibration Calibrator	AT01/3015	AP Technology	10 Sep 21	TCRT19/1709

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

Calibration checks were carried out on the meters and their measurement chains at the beginning and end of the survey. No significant calibration deviation occurred.

Noise indices

Noise indices recorded included the following:

- $L_{Aeq,T}$ The A-weighted equivalent continuous sound pressure level over a period of time, T.
- $L_{AFmax,T}$ The A-weighted maximum sound pressure level that occurred during a given period, T, with a fast time weighting.
- $L_{ASmax,T}$ The A-weighted maximum sound pressure level that occurred during a given period, T, with a slow time weighting.
- $L_{A90,T}$ The A-weighted sound pressure level exceeded for 90% of the measurement period. Indicative of the background sound level.

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*.

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 6841:2008).
- The maximum RMS acceleration levels in each of three axes in one-third-octave bands, measured using the 'slow response' exponential time weighting.

Weather conditions

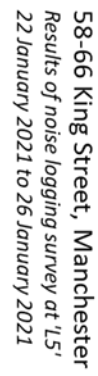
During the attended noise measurements, the weather was generally clear and dry and no rain occurred.

During the unattended noise measurements, weather reports for the area indicated that temperatures varied between -3°C at night and 6°C during the day, and the wind speed was less than 4 m/s.

These weather conditions are considered suitable for obtaining representative measurements.

Appendix B

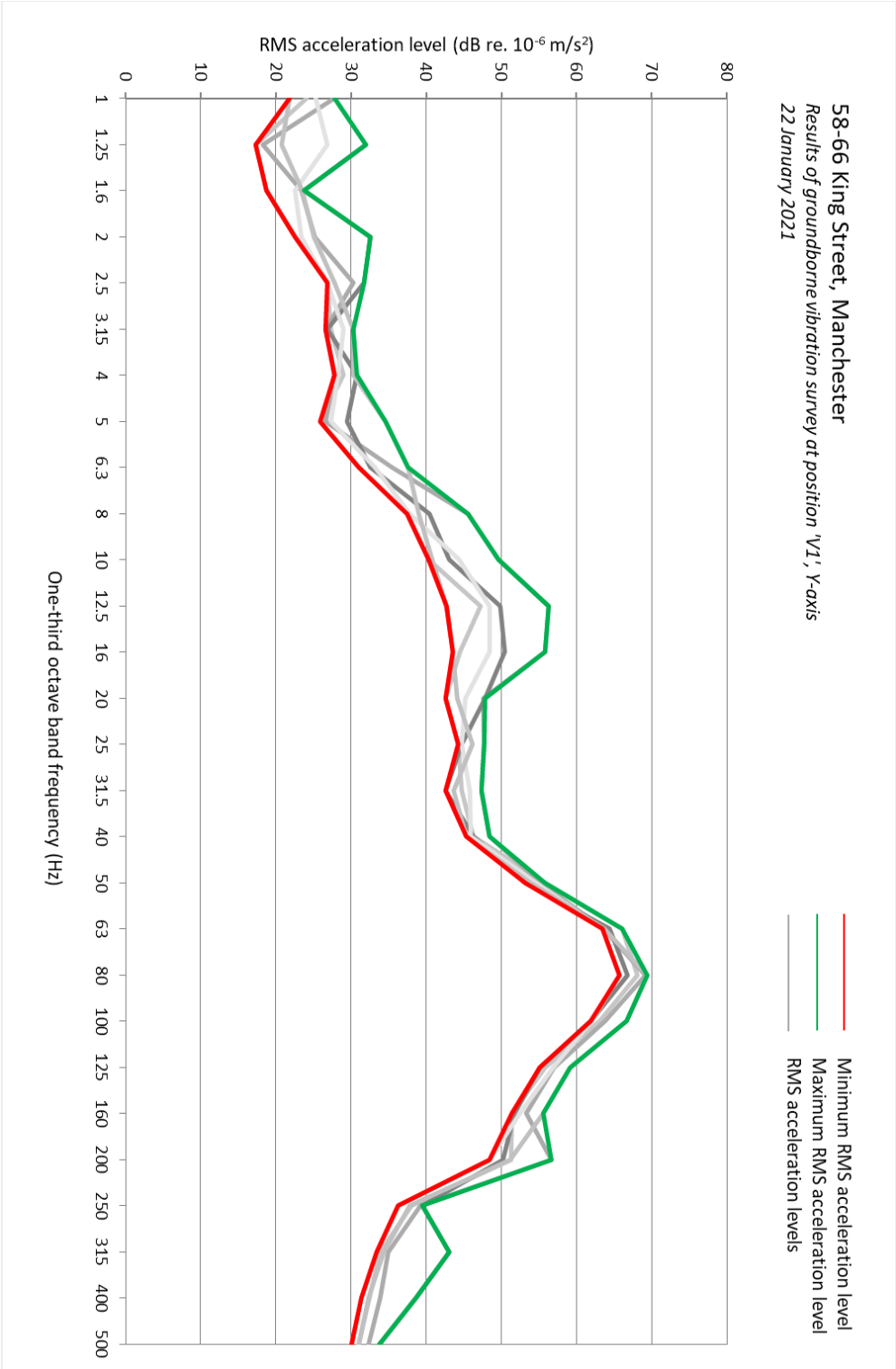
Results of unattended measurements at Location 'L5'



Appendix C

Measured RMS acceleration results at Location 'V1'







Appendix D

BS 4142 corrections for attention catching features

The following applies where plant noise is assessed in accordance with BS 4142:2014+A1:2019.

If the proposed plant noise contains attention catching features (such as tonal elements, whines, whistles, bangs etc), penalty corrections should be applied based on the type and impact of the features.

If appropriate, a subjective assessment of the plant features can be adopted. Where the plant noise contains tonal elements, the following corrections can be made depending on how perceptible the tone is at the noise receptor:

- 0 dB where the tone is not perceptible
- 2 dB where the tone is just perceptible
- 4 dB where the tone is clearly perceptible
- 6 dB where the tone is highly perceptible.

Where the plant noise is impulsive, the following corrections can be made depending on how perceptible the impulsivity is at the noise receptor:

- 0 dB where the impulse is not perceptible
- 3 dB where the impulse is just perceptible
- 6 dB where the impulse is clearly perceptible
- 9 dB where the impulse is highly perceptible.

For noise which is equally both impulsive and tonal, then both features can be accounted for by linearly summing the corrections for both characteristics.

If the plant has other distinctive characteristics, such as intermittency, then a 3 dB correction can be made.

If a subjective assessment of tonality is not appropriate, an objective assessment can be made by analysis of time-averaged, third-octave band sound pressure levels. A noise source is deemed to be tonal if the level in a third-octave band exceeds the level in adjacent third-octave bands by the level differences given below:

- 15 dB in the low frequency third-octave bands (25 Hz to 125 Hz)
- 8 dB in the mid frequency third-octave bands (160 Hz to 400 Hz)
- 5 dB in the high frequency third-octave bands (500 Hz to 10000 Hz).

If an objective assessment identifies the plant noise to be tonal then a 6 dB correction must be made.

Appendix E

Plant noise egress calculations

Comments	Octave band centre frequency (Hz)								Rating 1	Rating 2
	63	125	250	500	1k	2k	4k	8k		
22/09/2021										
20270 - 58-66 King Street, Manchester										
Prepared by: Kane Mitchell										
Summary										
Calculations have been undertaken to assess noise egress to the worst affected noise sensitive premises.										
These are considered to be the following:										
37, 49 and 51 King Street to the north (commercial)										
56 King Street to the west (commercial)										
33 and 35 South King Street (residential)										
For each assessment, the condensers have been grouped into two groups to allow a more accurate assessment.										
Plant noise egress limits										
Maximum sound pressure level at 1 m from noise sensitive premises, LAeq,15min (dB)										
Daytime Laeq (dB)									LA=	45.0
Night-time Laeq (dB)									LA=	44.0
Plant data received - Sound pressure level at 1m										
Large typical condenser units	51	52	49	47	43	39	30	24	LA=	48
Small typical condenser units	49	50	47	45	41	37	28	22	LA=	46
The above sound pressure data is measured hemispherically and no ground reflection corrections have been made.										
Assessment to north receptors 37, 49 and 51 King Street (commercial)										
Condenser bank 1 (North)										
	Sound pressure level at 1m Laeq (dB)									
1	49	50	47	45	41	37	28	22		
2	49	50	47	45	41	37	28	22		
3	49	50	47	45	41	37	28	22		
5	51	52	49	47	43	39	30	24		
7	51	52	49	47	43	39	30	24		
9	49	50	47	45	41	37	28	22		
10	49	50	47	45	41	37	28	22		
12	51	52	49	47	43	39	30	24		
14	51	52	49	47	43	39	30	24		
19	51	52	49	47	43	39	30	24		
21	51	52	49	47	43	39	30	24		
Cumulative SPL from B1 (dB)	61	61	59	57	53	48	40	33	LA=	58
Transmission path over the louvres										
Barrier attenuation	5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=17	-25	-25	-25	-25	-25	-25	-25	-25		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	34	35	32	30	26	22	13	7	LA=	31
Transmission path through the louvres										
Louvre insertion losses (dB)	5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=17	-25	-25	-25	-25	-25	-25	-25	-25		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	34	36	32	30	23	15	6	2	LA=	30
SPL from B1 at receptor (dB)	37	38	35	33	28	22	14	8	LA=	34
Condenser bank 2 (South)										
	Sound pressure level at 1m Laeq (dB)									
4	51	52	49	47	43	39	30	24		
6	51	52	49	47	43	39	30	24		
8	49	50	47	45	41	37	28	22		

11	51	52	49	47	43	39	30	24		
13	51	52	49	47	43	39	30	24		
15	51	52	49	47	43	39	30	24		
16	49	50	47	45	41	37	28	22		
17	49	50	47	45	41	37	28	22		
18	51	52	49	47	43	39	30	24		
20	51	52	49	47	43	39	30	24		
22	51	52	49	47	43	39	30	24		
23	51	52	49	47	43	39	30	24		
24	51	52	49	47	43	39	30	24		
Cumulative SPL (dB) from B2	62	62	60	58	54	49	41	34	L _A =	59
Transmission path over the louvres										
Barrier attenuation	5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=20	-26	-26	-26	-26	-26	-26	-26	-26		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	34	34	32	30	26	21	13	6	L _A =	31
Transmission path through the louvres										
Louvre insertion losses (dB)	5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=20	-26	-26	-26	-26	-26	-26	-26	-26		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	34	35	32	30	23	14	6	1	L _A =	30
SPL from B2 at receptor (dB)	37	38	35	33	27	22	14	7	L _A =	34
Cumulative SPL at receptor (dB)	40	41	38	36	31	25	17	11	L _A =	37

Assessment to west receptor 56 King Street (commercial)

Condenser bank 1 (West)										
			Sound pressure level at 1m Laeq (dB)							
4	51	52	49	47	43	39	30	24		
6	51	52	49	47	43	39	30	24		
11	51	52	49	47	43	39	30	24		
12	51	52	49	47	43	39	30	24		
13	51	52	49	47	43	39	30	24		
18	51	52	49	47	43	39	30	24		
20	51	52	49	47	43	39	30	24		
21	51	52	49	47	43	39	30	24		
24	51	52	49	47	43	39	30	24		
Cumulative SPL from B1 (dB)	61	61	59	57	53	48	40	33	L _A =	58
Transmission path over the louvres										
Barrier attenuation	5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=7	-17	-17	-17	-17	-17	-17	-17	-17		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	42	42	40	38	34	29	21	14	L _A =	39
Transmission path through the louvres										
Louvre insertion losses (dB)	5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=7	-17	-17	-17	-17	-17	-17	-17	-17		
3dB facade reflection	3	3	3	3	3	3	3	3		
SPL at receptor (dB)	42	43	40	38	31	22	14	9	L _A =	38
SPL from B1 at receptor (dB)	45	46	43	41	35	30	21	15	L _A =	41
Condenser bank 2 (East)										
			Sound pressure level at 1m Laeq (dB)							
2	49	50	47	45	41	37	28	22		
8	49	50	47	45	41	37	28	22		

	15	51	52	49	47	43	39	30	24		
	16	49	50	47	45	41	37	28	22		
	17	49	50	47	45	41	37	28	22		
	19	51	52	49	47	43	39	30	24		
	22	51	52	49	47	43	39	30	24		
	23	51	52	49	47	43	39	30	24		
Cumulative SPL from B2 (dB)		59	60	57	55	51	47	38	32	L _A =	57
Transmission path over the louvres											
Barrier attenuation		5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=10		-20	-20	-20	-20	-20	-20	-20	-20		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		37	38	35	33	29	25	16	10	L _A =	35
Transmission path through the louvres											
Louvre insertion losses (dB)		5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=10		-20	-20	-20	-20	-20	-20	-20	-20		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		37	39	35	33	26	18	9	5	L _A =	33
SPL from B2 at receptor (dB)		40	41	38	36	31	25	17	11	L _A =	37
Cumulative SPL at receptor (dB)		46	47	44	42	37	31	23	17	L _A =	43

Assessment to west receptor 33 and 25 South King Street (residential)

Condenser bank 1 (West)

		Sound pressure level at 1m Laeq (dB)									
	4	51	52	49	47	43	39	30	24		
	6	51	52	49	47	43	39	30	24		
	11	51	52	49	47	43	39	30	24		
	12	51	52	49	47	43	39	30	24		
	13	51	52	49	47	43	39	30	24		
	18	51	52	49	47	43	39	30	24		
	20	51	52	49	47	43	39	30	24		
	21	51	52	49	47	43	39	30	24		
	24	51	52	49	47	43	39	30	24		
Cumulative SPL from B1 (dB)		61	61	59	57	53	48	40	33	L _A =	58

Transmission path over the louvres

Barrier attenuation		5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=45		-33	-33	-33	-33	-33	-33	-33	-33		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		25	26	23	21	17	13	4	-2	L _A =	23

Transmission path through the louvres

Louvre insertion losses (dB)		5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=45		-33	-33	-33	-33	-33	-33	-33	-33		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		25	27	23	21	14	6	-3	-7	L _A =	22

SPL from B1 at receptor (dB)		28	30	26	24	19	14	5	-1	L _A =	25
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Condenser bank 2 (East)

		Sound pressure level at 1m Laeq (dB)									
	2	49	50	47	45	41	37	28	22		
	8	49	50	47	45	41	37	28	22		
	15	51	52	49	47	43	39	30	24		
	16	49	50	47	45	41	37	28	22		
	17	49	50	47	45	41	37	28	22		
	19	51	52	49	47	43	39	30	24		

	22	51	52	49	47	43	39	30	24		
	23	51	52	49	47	43	39	30	24		
Cumulative SPL from B2 (dB)		59	60	57	55	51	47	38	32	L _A =	57
Over the louvres											
Barrier attenuation		5	5	5	5	5	5	5	5		
20log(r1/r2), r1=1, r2=45		-33	-33	-33	-33	-33	-33	-33	-33		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		24	25	22	20	16	12	3	-3	L _A =	21
Through the louvres											
Louvre insertion losses (dB)		5	4	5	5	8	12	12	10		
20log(r1/r2), r1=1, r2=48		-34	-34	-34	-34	-34	-34	-34	-34		
3dB facade reflection		3	3	3	3	3	3	3	3		
SPL at receptor (dB)		24	25	22	20	13	4	-4	-9	L _A =	20
SPL from B2 at receptor (dB)		27	28	25	23	18	12	4	-2	L _A =	24
Cumulative SPL at receptor (dB)		31	32	29	27	22	16	8	1	L _A =	28