SANDY BROWN

Consultants in Acoustics, Noise & Vibration

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Upper and Lower Campfields, Manchester

Acoustic planning report

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A	11 Sep 23		Daniel Shaw	Matthew Robinson
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C	9 Oct 23	MEP drawings updated	Daniel Shaw	Matthew Robinson
D	26 Feb 24	MEP and operational noise update	Daniel Shaw	Matthew Robinson
E	4 Mar 24	Added calculations in Appendix D	Daniel Shaw	Matthew Robinson

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Summary

Sandy Brown has been commissioned by Allied London to provide acoustic advice in relation to the proposed development at Upper and Lower Campfields in Manchester.

An environmental noise survey has been carried out to determine the existing sound levels in the area. The noise survey was carried out between 11:15 on Thursday 20 April 2023 and 14:00 on Monday 24 April 2023

Based on the requirements of 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:

- $L_{Aeq,15min}$ 39 dB during the day, and $L_{Aeq,15min}$ 35 dB during the night at the rear of the development
- $L_{Aeq,15min}$ 44 dB during the day, and $L_{Aeq,15min}$ 40 dB during the night at the front of the development facing Liverpool Road.

These limits are cumulative, and apply with all plant operating under normal conditions. If plant items contain tonal or attention catching features, a penalty based on the type and impact of those features will be applied, and the limits will be more stringent than those set.

An initial assessment of plant noise egress has been carried out. In order to meet the limits, some mitigation measures are required, including sound absorbent finishes within plant rooms, acoustic louvres to the Chiller plant room and in-duct attenuation to the kitchen extract in Lower Campfield.

Due to the historical retained facade, to control operational noise egress, regular events within Lower Campfield are expected to be limited to light background music and dialogue-focussed screenings.

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1 Introduction

Sandy Brown has been commissioned by Allied London to provide acoustic advice in relation to the proposed development at Upper and Lower Campfields in Manchester.

As part of this, an environmental noise survey is required, the purpose of which is to establish the existing sound levels on and around the site.

Ambient and maximum noise levels are used to assess building envelope sound insulation requirements to achieve appropriate internal noise levels and operational noise egress. The measured levels are also used to set limits for plant noise egress. These follow standards set in accordance with Manchester City Council guidelines.

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

2 Site description

2.1 The site and its surrounding

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

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

The site is generally surrounded by busy city centre roads, quieter back streets and distant tram (Metrolink) and railway lines.

Upper Campfield, the smaller of the two, is bound by Liverpool Road to the south, Tonman Street to the north, Barton Street to the west and borders directly onto several restaurants to the east, with Deansgate slightly further east.

Lower Campfield, the larger of the two, is bound by Liverpool Road to the south, a pedestrianised section of Tonman Street to the north, Lower Byrom Street to the west, and Byrom Street to the east.

2.2 Adjacent premises

The north of the site is characterised by low rise residential apartment buildings, highlighted yellow in Figure 1. Beetham's tower, comprising a mix of hotel and apartments, also overlooks the site across Deansgate.

To the south on Liverpool Road, and further to the east on Deansgate are a number of restaurants, pubs and bars, highlighted blue in Figure 1. Where there are residential apartments above restaurants and bars, these have been highlighted green.

Office accommodation is located between the two market sites, as well as in some locations on Liverpool Road and Deansgate. These have been highlighted orange in Figure 1.

To the west of Lower Campfield, across Lower Byrom Street is the Museum of Science and Industry, highlighted pink in Figure 1.

3 Development proposals

3.1 Description of development

The development is to comprise a combination of shared workspace, private offices, studios and cafe/event spaces across the two former Campfield Market buildings.

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 Plant noise egress

4.1.1 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 nearby 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 sound 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.

4.1.2 Manchester City Council

Manchester City Council (MCC) provides guidance in relation to plant noise emissions in their *Planning and Noise Technical Guidance* document dated December 2022. The following criteria are stipulated:

a) 'achieve a noise level (L_{Aeq}) of at least 5 dB below the typical background noise levels (L_{A90}) at the nearest noise sensitive location at the quietest time the equipment will be in operation; and

b) not contain any discernible tonal characteristics at the nearest noise sensitive location at the quietest time the equipment will be in operation.

Where the product data suggests there may be a tonal element to the noise (i.e. the octave band noise data shows a peak at a particular frequency) it will be required to demonstrate that noise from the equipment will be at least 5 dB below the typical background noise level (L_{90}) in each octave band at the nearest noise sensitive location at the time the equipment will be in operation, the assessment will be carried out in line with BS4142: 2014.'

4.2 Operational noise egress

Manchester City Council require that:

> 'Entertainment noise ($L_{eq,5min}$) should be controlled to 5 dB below the typical background noise level (L_{90}) in each octave band at the nearest noise sensitive location.'

5 Noise survey method

The survey included unattended and attended noise measurements.

5.1 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 5 minute periods between 11:15 on Thursday 20 April 2023 and 14:00 on Monday 24 April 2023

The measurement positions used during the survey are indicated in Figure 1, denoted by the letters ‘A’ and ‘B’. Photographs showing the measurement locations are provided below. These locations were chosen to be reasonably representative of noise levels at the site and outside the nearest noise sensitive premises.

Figure 2 Photograph of measurement position 'A'

Figure 3 Photograph of measurement position 'B'

5.2 Attended measurements

Attended sample measurements were taken at 7 locations around the site. These are indicated in Figure 1 as positions 1 to 7. The measurements were carried out on Monday 24 April 2023, over 5 minute periods.

At each position the microphone was mounted on a tripod approximately 1.2 m above the ground level and 1 m from the facades of the buildings. Details of the equipment used and the noise indices measured are provided in Appendix A.

Dominant noise sources occurring during the measurements were noted.

Figure 4 Photographs of measurement position 1

Figure 5 Photographs of measurement position 2

Figure 6 Photographs of measurement position 3

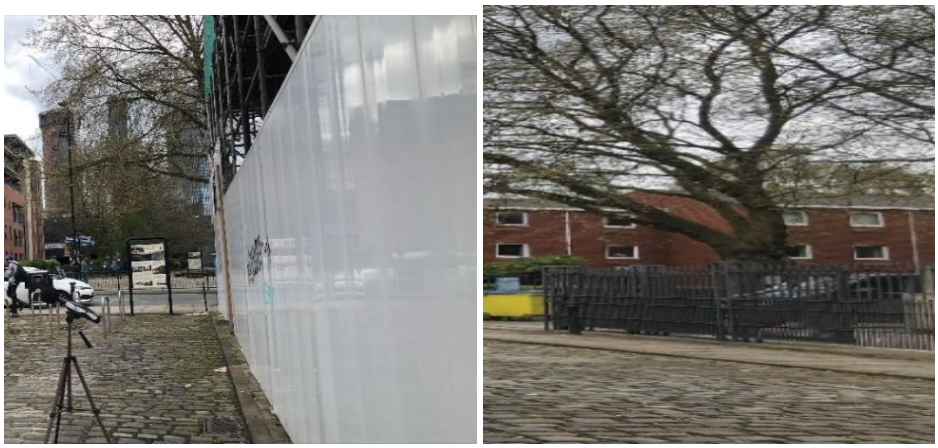


Figure 7 Photographs of measurement position 4

Figure 8 Photographs of measurement position 5

Figure 9 Photographs of measurement position 6

Figure 10 Photograph of measurement position 7

5.3 Weather conditions

Weather conditions during the survey are described in Appendix A.

6 Noise survey results

6.1 Observations

The dominant noise sources observed at the site during the survey were road traffic on Liverpool Road and Deansgate, and distant construction work at the Viadux development to the east of Beetham's tower.

Less significant noise sources included pedestrians and cars on the back streets. Trains on the Castlefield viaducts were not distinctly audible, and did not contribute significantly to the perceived noise levels.

6.2 Noise measurement results

6.2.1 Unattended measurement results

A graph showing the results of the unattended measurements at Position A is provided in Appendix B. Ambient noise levels measured during the unattended survey are presented in Table 1. These are measurements in facade conditions – ie, 1 m from the facade.

Table 1 Ambient noise levels measured during the unattended survey – Position A

Date	Day (07:00 – 23:00) $L_{Aeq,16h}$ (dB)	Night (23:00 – 07:00) $L_{Aeq,8h}$ (dB)
Thursday 20 April 2023	51 [1]	49
Friday 21 April 2023	52	51
Saturday 22 April 2023	50	50
Sunday 23 April 2023	51	49
Monday 24 April 2023	48 [1]	-
Average	51	50

[1] Measurements not taken over the full daytime period – not included in the average

Statistical analysis of the background noise levels is provided in Figure 11 below.

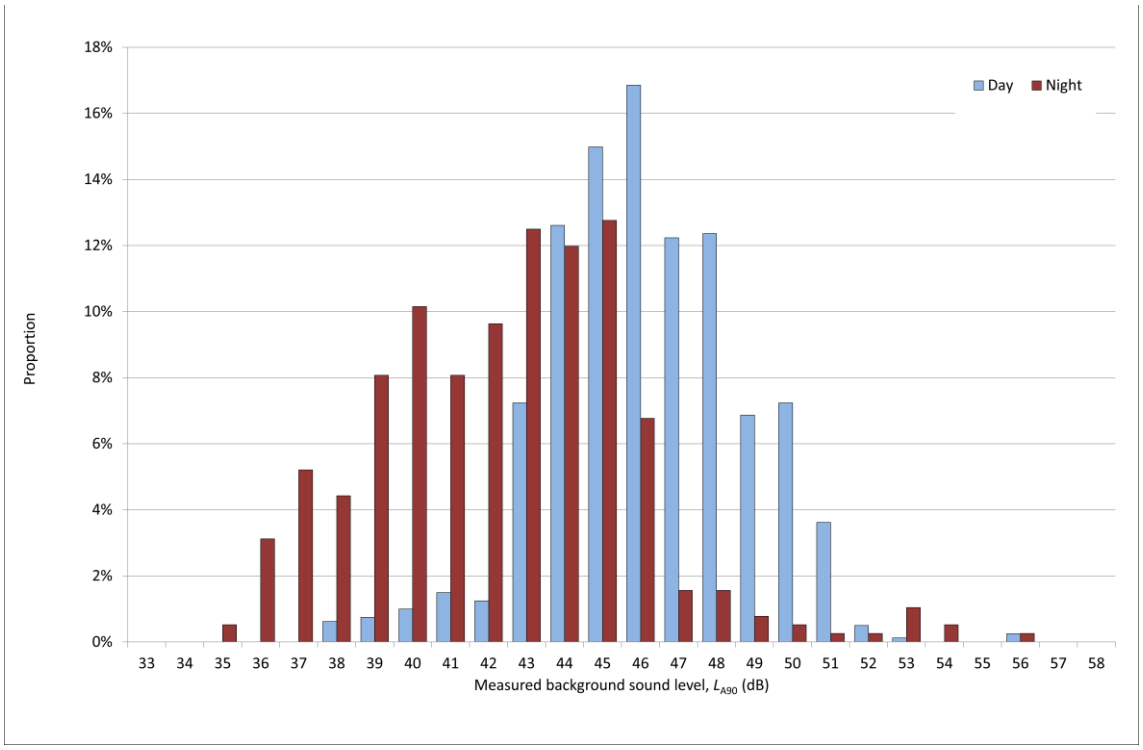


Figure 11 Histogram of the background noise levels, L_{A90} at Position A during the survey

Based on the statistical analysis, the representative background noise levels at the north of the site are L_{A90} 44 dB during the day and L_{A90} 40 dB during the night.

The noise levels measured at position B during the survey are presented in Table 2 below. These are also in facade conditions.

Noise at position B was dominated by traffic on Liverpool road, with lesser contributions of pedestrians, distant road noise from Deansgate, and construction at Viadux.

Table 2 Noise levels from unattended measurements – Position B

Start time	Sound pressure levels (dB)		
	$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$
11:35	68	80	54
11:40	67	76	55
11:45	66	78	52
11:50	66	77	52

Start time	Sound pressure levels (dB)		
	$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$
11:55	65	76	53
12:00	67	79	53
12:05	67	79	52
12:10	68	78	55
12:15	65	76	53
12:20	66	76	54
12:25	67	82	52
12:30	66	78	53
12:35	68	80	54
12:40	67	76	52
12:45	67	76	55
12:50	66	76	54
12:55	68	82	54
13:00	66	78	54
13:05	68	79	56
13:10	66	77	54
13:15	67	78	52
13:20	68	76	55
13:25	66	77	54
13:30	67	78	54
13:35	67	80	53
13:40	68	77	53
13:45	67	75	54
13:50	68	77	56
13:55	69	77	57

The average noise level measured at position B was L_{Aeq} 67 dB. The maximum noise level measured was L_{AFmax} 82 dB. The minimum background noise level measured was L_{A90} 52 dB.

The minimum background noise level at Position A during the measurements at Position B was L_{A90} 47 dB. As such, noise levels at the front of the site facing Liverpool Road are understood to be 5 dB louder than those at the rear of the site.

6.2.2 Attended measurement results

Noise levels and key sources recorded during the attended measurements are summarised in Table 3.

Table 3 Noise levels and key noise sources from attended measurements

Position	Start time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$	
1	12:10	59	80	50	Deansgate road traffic, construction at Viadux, infrequent car pass-bys on back streets, cyclists, pedestrians
	12:15	55	64	50	
	12:21	56	65	50	
2	12:35	59	74	48	Liverpool Road traffic, Viadux construction, infrequent car pass-bys on cobble street, occasional pedestrians
	12:40	59	71	49	
	12:45	58	66	49	
3	12:50	67	77	56	Dominated by Liverpool Road and Deansgate traffic, occasional pedestrian chatter
	12:55	69	88	59	
	13:00	68	79	57	
4	13:10	58	72	50	Liverpool Road traffic, Viadux construction, infrequent pedestrians
	13:15	60	70	51	
	13:20	61	72	52	
5	13:25	49	69	44	Mostly pedestrian noise, indirect traffic noise, construction at Viadux

Position	Start time	Sound pressure levels (dB)			Noise sources
		$L_{Aeq,5min}$	$L_{AFmax,5min}$	$L_{A90,5min}$	
6	13:30	65	80	53	Lower Byrom Street heavy vehicle traffic, Liverpool Road general traffic, general pedestrian activity
	13:37	68	84	57	
	13:42	65	77	56	
7	13:50	66	75	59	Dominated by Liverpool Road traffic.

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 below.

The limits apply at 1 m from the worst affected windows of the nearest noise sensitive premises and are presented as facade levels.

Table 4 Plant noise limits at 1 m from the nearest noise sensitive premises

Time of day	Location	Maximum sound pressure level at 1 m from noise sensitive premises, $L_{Aeq,15min}$ (dB)
Day (07:00-23:00)	Rear	39
	Liverpool Road	44
Night (23:00-07:00)	Rear	35
	Liverpool Road	40

[1] The limits set out above do not include any attention catching features. 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 C.

7.1 Emergency plant limits

Relaxations of 10 dB over the limits above may be considered for emergency plant items operating for a short period, as accepted on other projects in Manchester.

7.2 Plant noise assessment

7.2.1 Proposed plant – Lower Campfield

For Lower Campfield, a heat pump and several condensers are proposed within internal plant areas with louvres to the atmosphere, with the locations shown below.

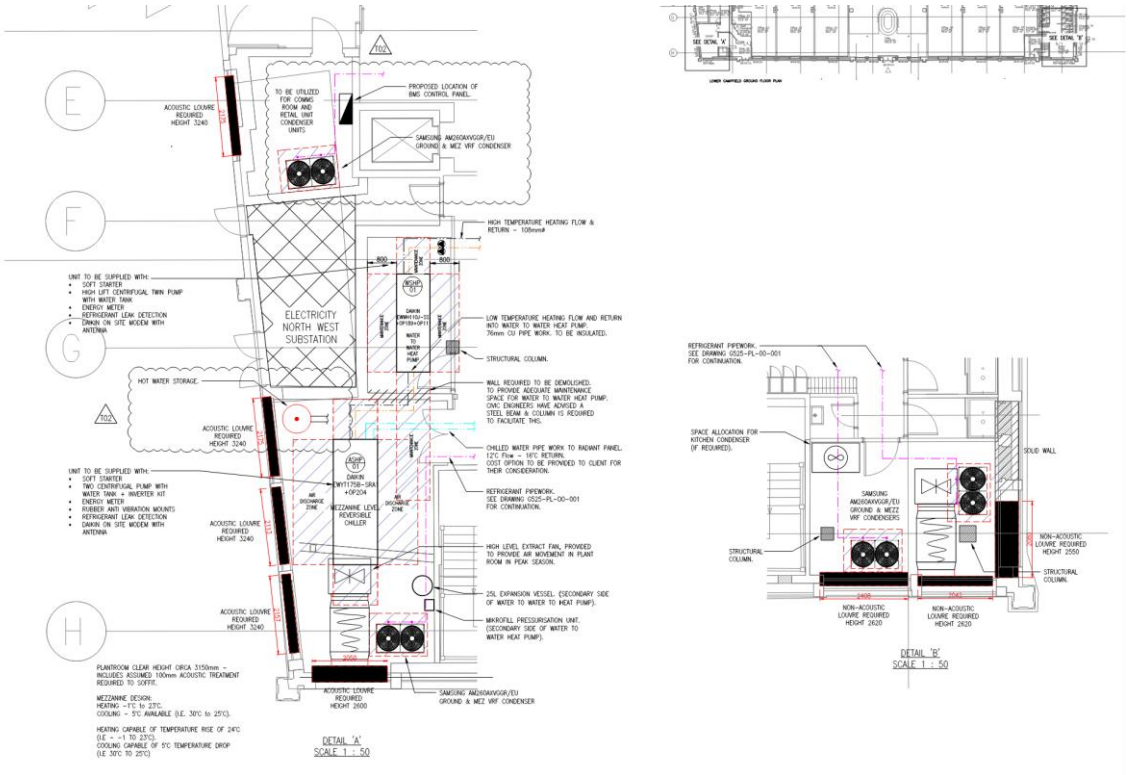


Figure 12 Proposed locations of internal plant items

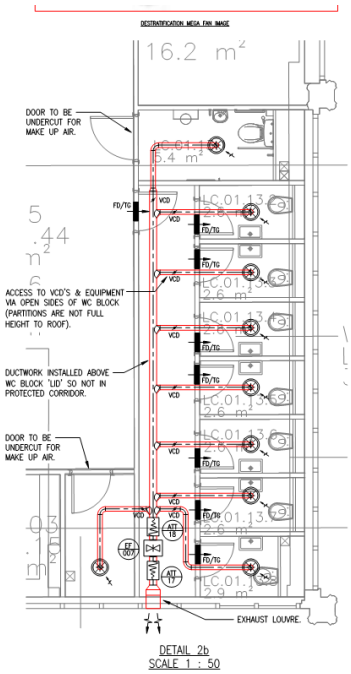


Figure 13 Lower Campfield toilet extract location

The proposed items include:

- Daikin EWWH110J Water-water heat pump (L_{wA} 89 dB, L_{Aeq} 79 dB at 1 m from unit)
- Daikin EWYT175B Air Source Heat Pump (L_{wA} 85 dB, L_{Aeq} 67 dB at 1 m)
- 4x Samsung AM260AXVGGR/EU condensers (L_{Aeq} 65 dB at 1 m in cooling mode).

These plant items are not typically noted to be tonal or intermittent, and as such no attention catching features have been included within the assessment.

There is also a kitchen extract louvre at high level on the rear wall of Lower Campfield.

Plant item	Sound pressure level at 1 m from unit (dB) Octave-band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Daikin EWWH110J water-water heat pump	65	69	74	79	74	71	59	56
Daikin EWYT175B ASHP	66	67	62	62	63	61	54	46

7.2.2 Proposed plant – Upper Campfield

Upper Campfield includes a plant room within the roof space above mezzanine level, with 7 VRF units proposed. The nearest receptors to this are 22 m from the facade of Upper Campfield, and 42 m from the centre where the plant room is located.

Each AC250KXAPNH VRF unit has a sound power level of L_{wA} 77 dB.

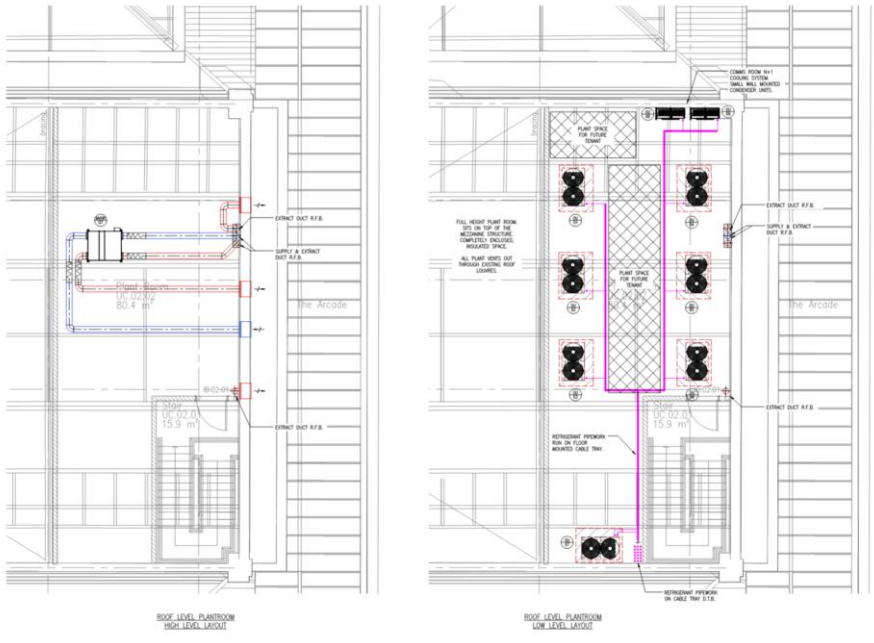


Figure 14 Upper Campfield plant room location

In addition, there are 6 MVHR units which terminate through the roof at several locations highlighted below, and 3 extract fans which terminate through the facade.

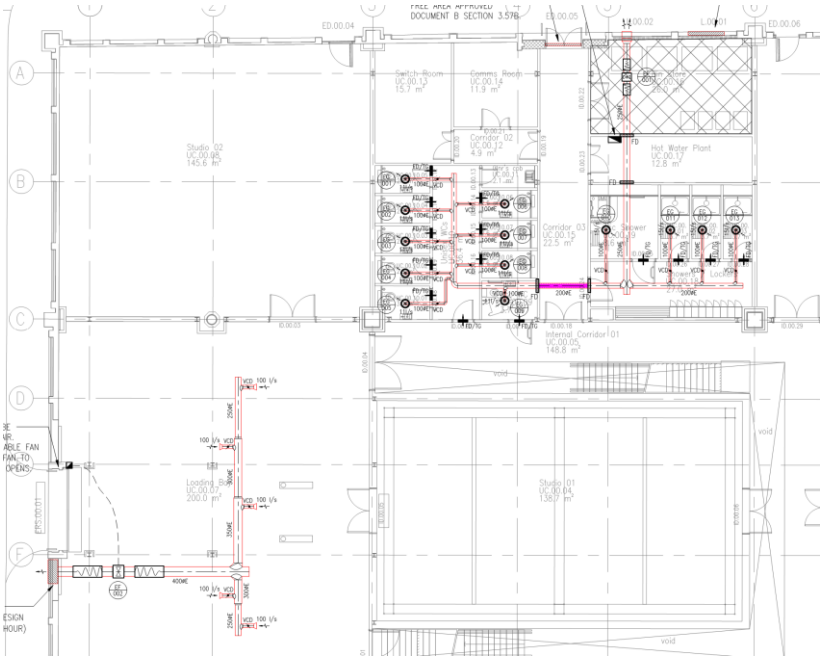


Figure 15 Extract fan routing

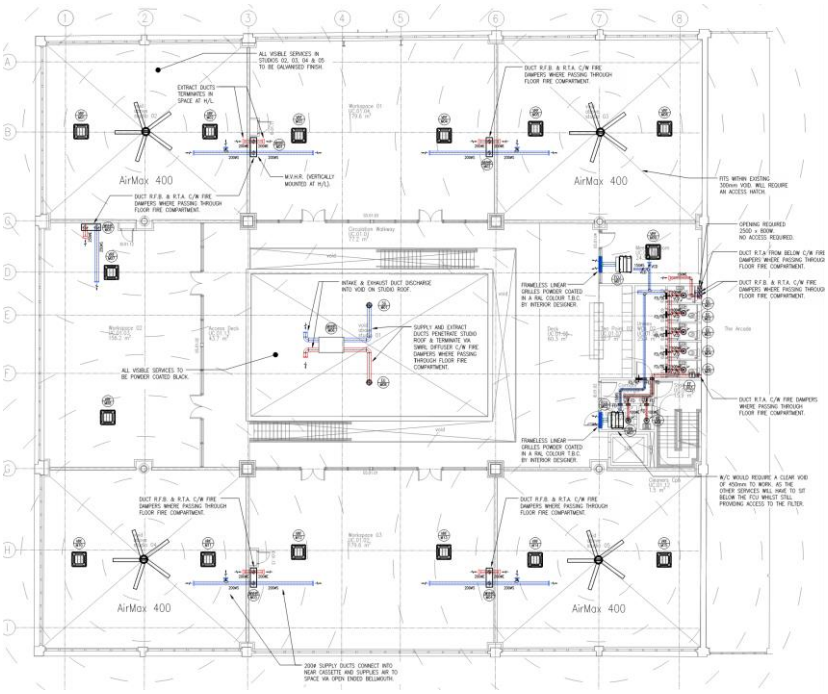


Figure 16 Upper Campfield - MVHR locations

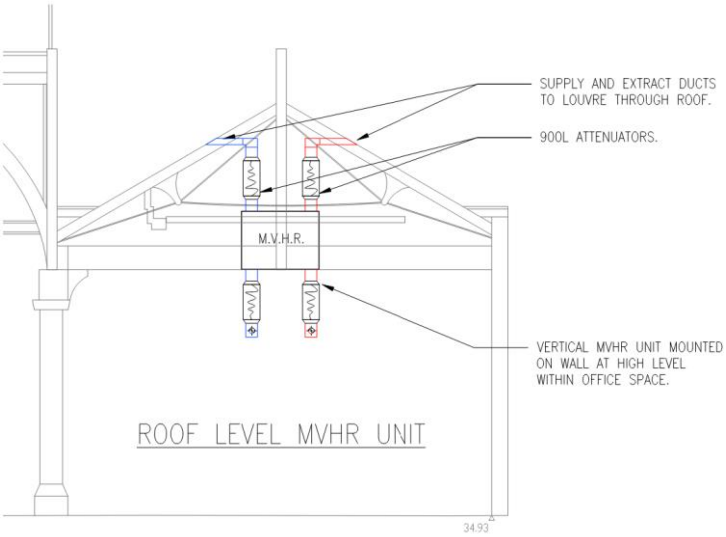


Figure 17 MVHR rooftop termination section drawing

7.2.3 Assessment – Lower Campfield – Eastern plant room

For noise egress from the heat pump to the receptors to the rear, the predicted levels are around L_{Aeq} 50 dB at 1 m from the facade. This is significantly higher than the limits, and mitigation measures will be required.

On the basis that plant cannot be re-selected for quieter models, Class A sound absorbent panels should be added to every available surface to minimise reverberant noise build-up. This would typically comprise 100 mm fleece-faced mineral fibre behind perforated metal.

The supplementary fans will need to be attenuated to meet a sound power level of L_{wA} 63 dB at the louvre.

It is expected that a setback in duty will be required to meet the limits during the night.

Calculations used for the assessment are provided in Appendix D.

7.2.4 Assessment - Lower Campfield – kitchen extract

The kitchen extract should be designed to be at least 10 dB below the noise egress from the eastern plant room to allow the overall limits to be met.

As such, the sound power limit at the louvre should be L_{wA} 57 dB. This will require careful selection and potentially in-line attenuators.

Calculations used for the assessment are provided in Appendix D.

7.2.5 Assessment – Lower Campfield – Western plant rooms

Noise levels from the western plant room to receptors on Liverpool Road are around L_{Aeq} 69 dB, which significantly exceeds the daytime limits.

To meet the limits, 100 mm deep Class A sound absorption should be added to all available surfaces within the plant room.

On the basis that this can be included, acoustic louvres should be installed to provide at least a 16 dBA reduction. This is typically achieved by 300-600 mm acoustic louvres which may increase the pressure on the system and reduce the available free air.

The supplementary fans should be attenuated to meet a sound power limit of L_{wA} 64 dB at the louvre.

It is expected that a 4 dB setback in duty will be required to meet the limits during the night.

Calculations used for the assessment are provided in Appendix D.

7.2.6 Assessment – Upper Campfield

Based on atmospheric connections terminating at the roof level, and assuming no screening, any plant serving Upper Campfield should have a limit of L_{wA} 76 dB at the plant room louvre to meet the daytime requirements.

The proposed plant items exceed this limit for even a single unit. As such, the plant should be attenuated by 9 dBA, and the plant room lined with Class A 100 mm sound absorbent material.

Each MVHR atmospheric termination should be limited to L_{wA} 50 dB, which will require in-duct attenuation and selection of low-noise models.

Each extract fan atmospheric termination should be limited to L_{wA} 40 dB, which will require in-duct attenuation and selection of low-noise models.

It is expected that a minimum 4 dB setback in duty would occur during the night to allow the night-time limits to be met. Any screening or other mitigation measures would allow higher levels within the plant room.

Calculations used for the assessment are provided in Appendix D.

8 Operational noise egress

8.1 Operational noise

8.1.1 Operational noise egress

Manchester City Council, MCC, typically require music noise egress to be 5 dB below the existing background levels at the receptors as measured at 1 m from the facade. Broadband limits are presented below.

Table 5 Operational noise limits at 1 m from the nearest noise sensitive premises

Time of day	Location	Maximum sound pressure level at 1 m from noise sensitive premises, $L_{Aeq,15min}$ (dB)
Day (07:00-23:00)	Rear	39
	Liverpool Road	44
Night (23:00-07:00)	Rear	35
	Liverpool Road	40

8.1.2 Facade sound insulation

This section describes an assessment of facade sound insulation to control noise egress.

For the ground floor of Lower Campfield, noise ingress would be suitably controlled by the proposed construction of:

- typical standard thermal double glazing infill (6 mm glazing/ 12 air-space/6 mm glazing)
- solid 140 mm concrete block masonry constructions.

The ventilation louvres proposed over the windows should provide a sound insulation performance of at least $D_{n,e,w}$ 30 dB.

For the ground floor of Upper Campfield, where it is enclosed, the existing insulated panel with metal profile is expected to provide in the region of R_w 20 dB.

However, on the upper floors of Lower and Upper Campfield, the roofs and facade are expected to provide a lower overall sound insulation performance due to the retained single glazing, timber facade, timber roof, and open timber louvres.

The combined facade is expected to be limited to around R_w+C_{tr} 13 dB without the use of secondary glazing, internal linings to the roof, or acoustic louvres.

8.1.3 Guidance on maximum internal amplified sound levels

Maximum internal amplified sound limits will need to be set using electronic limiters to ensure that the amplified sound egress limits are not exceeded. These should be set following pre-completion testing to establish the sound insulation provided.

Based on the proposed minimum standards of sound insulation for the floor and facades, and the proposed breakout/transfer criteria, guidance is provided on maximum amplified sound limits in these areas.

Maximum operational noise levels (L_{eq}) from amplified sound within the proposed event space are set out in Table 6 below. These are equivalent to L_{Aeq} 76 dB and L_{Aeq} 72 dB.

Table 6 Guideline internal operational noise limits

Period	Guideline maximum internal reverberant noise levels, $L_{eq,1min}$ (dB)						
	Octave-band centre frequency (Hz)						
	63	125	250	500	1000	2000	4000
Day (07:00-23:00)	72	68	71	72	74	69	58
Night (23:00-07:00)	68	64	67	68	70	65	54

Maximum internal sound pressure levels (L_{Fmax}) should be limited to values 10 dB above those set out.

This is in line with light background music and dialogue-focussed film screenings.

9 Conclusion

A noise survey has been carried out at the site. Key noise sources at the site were noted as traffic on Liverpool Road and Deansgate.

Measured ambient noise levels were in the range:

- $L_{Aeq,5min}$ 50 to 68 dB during the day, and
- $L_{Aeq,5min}$ 49 to 51 during the night.

The typical background sound levels measured during the survey:

- At the rear of the site were:
  - $L_{A90,5min}$ 44 dB during the day and
  - $L_{A90,5min}$ 40 dB at night.
- At the front of the site facing Liverpool Road were :
  - $L_{A90,5min}$ 49 dB during the day and
  - $L_{A90,5min}$ 45 dB at night.

The data collected has been used to determine appropriate plant noise egress limits and sound insulation requirements for the building envelope.

Due to the retained historical facade, noise egress limits are expected to restrict regular events to light background music or dialogue-focussed screenings.

To control plant noise egress, sound absorbent linings are required to the plant rooms, as well as acoustic louvres to the Chiller plant room. The kitchen extract will be specified to include in-duct attenuation. Attenuation is also required to all Upper Campfield plant items.

Appendix A

Survey details

Equipment

The unattended and attended noise measurements were both taken using Rion NL-52 sound level meters.

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	8 Sep 23	UCRT21/2089, UCRT21/2090
Microphone	4189/3100176	Brüel & Kjær	8 Sep 23	UCRT21/2089, UCRT21/2090
Pre-amp	ZC0032/26376	Brüel & Kjær	8 Sep 23	UCRT21/2089, UCRT21/2090
Calibrator	4231/3019123	Brüel & Kjær	8 Sep 23	UCRT21/2086
Sound level meter	NL-52/00932326	Rion	21 Mar 25	TCRT23/1250
Microphone	UC-59/05549	Rion	21 Mar 25	TCRT23/1250
Pre-amp	NH-25/32354	Rion	21 Mar 25	TCRT23/1250
Calibrator	NC-74/34125432	Rion	21 Mar 25	TCRT23/1248
Sound level meter	NL-52/01143564	Rion	15 Dec 24	TCRT22/1766
Microphone	UC-59/10153	Rion	15 Dec 24	TCRT22/1766
Pre-amp	NH-25/43581	Rion	15 Dec 24	TCRT22/1766
Calibrator	NC-74/34257023	Rion	15 Dec 24	TCRT22/1765

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.
- $L_{A90,T}$ 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.*

Weather conditions

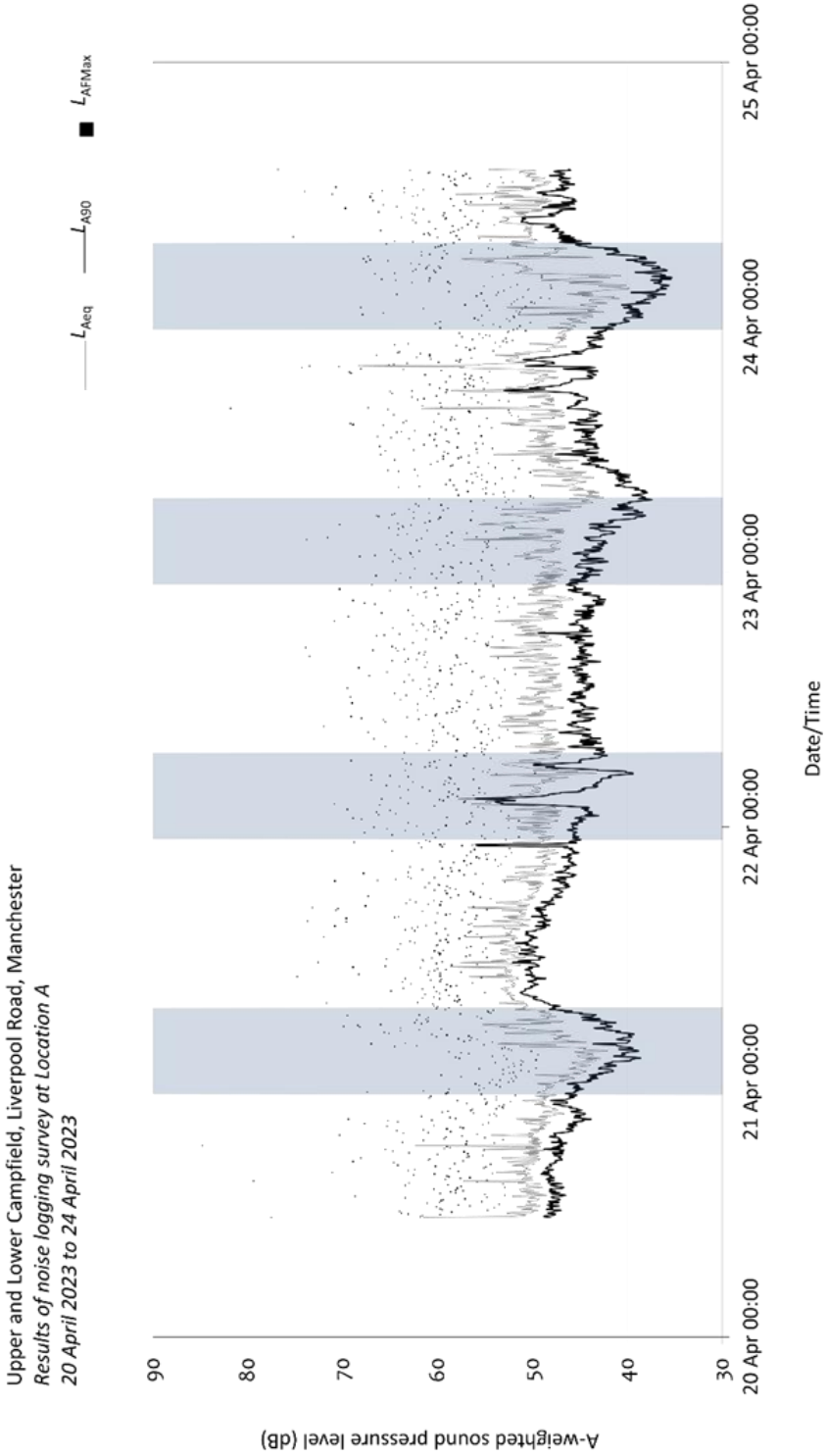
During the attended noise measurements, the weather was generally clear and dry and no rain occurred. Wind speeds were measured at each position and varied between 2 m/s and gusts of 5 m/s.

During the unattended noise measurements, weather reports for the area indicated that temperatures varied between 0°C at night and 16°C during the day, and the wind speed was generally less than 7 m/s.

These weather conditions are considered suitable for obtaining representative measurements.

Appendix B

Results of unattended measurements at Location A


Upper and Lower Campfield, Liverpool Road, Manchester
Results of noise logging survey at Location A
20 April 2023 to 24 April 2023
LAeq
LA90
LAFMax
A-weighted sound pressure level (dB)
90
80
70
60
50
40
30
20 Apr 00:00
21 Apr 00:00
22 Apr 00:00
23 Apr 00:00
24 Apr 00:00
25 Apr 00:00
Date/Time

Appendix C

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 D

Summary of plant noise egress calculations

Lower Campfield – western plant rooms

Sound power levels at the louvre are calculated by first converting from the combined sound power of all plant within the room to a reverberant sound pressure level – assuming a diffuse field.

$$L_{p,rev} = L_{w,plant} + 10*\log_{10}(4 / R)$$

Where R is the room constant and is dependent on the finishes within the rooms. It is calculated to be 13 for a room with no absorption, and 118 for a room with class A absorbers to all available surfaces.

An area correction is then applied to account for the area of the louvres:

$$L_{w,louvre} = L_{p,rev}\ 10*\log_{10}(A/A_0)$$

Where A_0 is 1 $m^{2.}$. The area of the louvres is shown in the planning drawings.

The insertion loss of acoustic louvres is applied at this stage.

A distance correction of r = 18 m is applied to the sound power emanating from the louvres:

$$L_{eq} = L_{w,louvre} + 10*\log_{10}(Q / 4\pi r^2)$$

Q is assumed to be 2 in line with hemispherical spreading.

A correction of 3 dB is then applied to the calculated sound pressure level to account for reflections from the facades of the receptors.

Table D1 Summary of plant noise egress calculations from western plant room

Calculation description	A-weighted value (dB)
Combined sound power levels, L_{wA}	91
Correction from sound power level to reverberant sound pressure level (with/without absorption treatment)	-15/-5
Area correction to louvres	14
Distance correction	-33
Facade correction	3
Predicted level at receptor (with/without absorption treatment), L_{Aeq}	60/69

Lower Campfield – eastern plant rooms

Sound power levels at the louvre are calculated by first converting from the combined sound power of all plant within the room to a reverberant sound pressure level – assuming a diffuse field.

$$L_{p,rev} = L_{w,plant} + 10*\log_{10}(4 / R)$$

Where R is the room constant and is dependent on the finishes within the rooms. It is calculated to be 17 for a room with no absorption, and 224 for a room with class A absorbers to all available surfaces.

An area correction is then applied to account for the area of the louvres:

$$L_{w,louvre} = L_{p,rev}\ 10*\log_{10}(A/A_0)$$

Where A_0 is 1 $m^{2.}$. The area of the louvres is shown in the planning drawings.

The insertion loss of acoustic louvres is applied at this stage.

A distance correction of r = 30 m to the worst-case receptors is applied to the sound power emanating from the louvres:

$$L_{eq} = L_{w,louvre} + 10*\log_{10}(Q / 4\pi r^2)$$

Q is assumed to be 2 in line with hemispherical spreading.

A correction of 3 dB is then applied to the calculated sound pressure level to account for reflections from the facades of the receptors.

Table D2 Summary of plant noise egress calculations from eastern plant room

Calculation description	A-weighted value (dB)
Combined sound power levels, L_{wA}	76
Correction from sound power level to reverberant sound pressure level (with/without absorption treatment)	-17.5/-6
Area correction to louvres	14
Distance correction	-37.5
Facade correction	3
Predicted level at receptor (with/without absorption treatment), L_{Aeq}	38/50

Lower Campfield – Operational noise egress

Operational noise egress limits have been calculated back from the limits at the receptors.

A distance correction of r = 24 m is applied to the sound power emanating from the louvres:

$$L_{w,facade} = L_{eq,limit} - 10*\log_{10}(Q / 4\pi r^2)$$

Q is assumed to be 2 in line with hemispherical spreading.

An octave-band screening correction is applied, averaging around 16 dBA reduction. This is calculated from the path difference, with a 1 m screen blocking line of sight between the receptors and the clerestory louvres.

A sound insulation performance of 13 dB is applied for a partially open louvre, in line with standard performances for openable windows.

An area correction is then applied to convert the sound power incident on the louvre to a reverberant sound pressure level in the space.

$$L_{p,rev} = L_{w,facade} - 10*\log_{10}(A/A_0)$$

Where A_0 is 1 $m^{2.}$. The area of the louvres is taken to be 150 m^2 as a worst case.

Night time limits are 4 dB below the daytime, with similar noise sources and background spectra. Internal limits 4 dB below the daytime have been set as a result.

Table D3 Summary of operational noise egress limit calculations

	Octave-band centre frequency (Hz)						
Calculation description	63	125	250	500	1000	2000	4000
Typical measured daytime background levels, L_{eq} (dB)	49	43	44	42	41	32	20
Limits at receptor 5 dB below plus 3 dB facade correction, L_{eq} (dB)	47	41	42	40	39	30	18
Distance correction back to sound power level, L_w (dB)	25	25	25	25	25	25	25
Screening attenuation insertion loss (dB)	9	11	13	16	19	22	24
Sound insulation of partially open window, (dB)	13	13	13	13	13	13	13
Area correction to convert to reverberant sound pressure level	-22	-22	-22	-22	-22	-22	-22

	Octave-band centre frequency (Hz)						
Calculation description	63	125	250	500	1000	2000	4000
Resultant internal reverberant sound pressure level limit, $L_{p,rev}$ (dB)	72	68	71	72	74	69	58

Upper Campfield – Plant noise egress

A distance correction of r = 42 m is applied to the sound power emanating from the louvres:

$$L_{eq} = L_{w,louvre} + 10*\log_{10}(Q / 4\pi r^2)$$

Q is assumed to be 2 in line with hemispherical spreading.

A correction of 3 dB is then applied to the calculated sound pressure level to account for reflections from the facades of the receptors.

This allows the specification of the sound power limit at the louvre.

A similar distance has been used for the calculation of noise egress from the MVHRs.

Table D4 Summary of plant noise egress calculations from Upper Campfield plant room

Calculation description	A-weighted value (dB)
Daytime limit at receptors, L_{Aeq}	39
Facade correction	-3
Distance correction from sound pressure to sound power	40
Louvre sound power limit, L_{wA}	76