

Hybrid Theatres Extension Royal Free London, London



Planning Compliance Report
Report 27942.PCR.01

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27942.TH1-2	Environmental Noise Time Histories
27942.Daytime L90.TH1-2	Statistical analysis for representative daytime L_{A90}
27942.Night-time L90.TH1-2	Statistical analysis for representative night-time L_{A90}
Appendix A	Glossary of Acoustics Terminology
Appendix B	Acoustic Calculations
Appendix C	Anti-Vibration Mounting Specification Reference Document

1.0 INTRODUCTION

KP Acoustics Ltd has been commissioned by RFL Property Services Ltd, Accounts Payable, Finance Department, Enfield Civic Centre (10th Floor), Silver Street, Enfield, EN1 3ES to undertake a noise impact assessment of a proposed plant unit installation. The installation is to serve the proposed delivery of a new extension to the existing hospital building, to deliver new hybrid theatres and associated works at Hybrid Theatres, Royal Free London, Pond Street, London, NW3 2QG.

This report has been prepared to support a planning application, submitted to the London Borough of Camden and proposing the following works at the Site:

“Proposed extension to hospital at second and third storey level (above ground) with undercroft area beneath to deliver extension to hybrid theatres alongside roof-level plant and enclosure and associated works.”

A 48-hour environmental noise survey has been undertaken on site in order to prepare a noise impact assessment in accordance with BS4142:2014 *‘Method for rating and assessing industrial and commercial sound’* as part of the planning requirements of the London Borough of Camden.

This report presents the methodology and results from the environmental survey, followed by calculations in accordance with BS4142 to provide an indication as to the likelihood of the noise emissions from the proposed plant unit installation having an adverse impact on the closest noise sensitive receiver. Mitigation measures will be outlined as appropriate.

2.0 SITE SURVEYS

2.1 Site Description

As shown in Figure 2.1, the site comprises a broadly rectangular area located to the immediate west of the existing main Royal Free London Hospital building. The site is bounded by the Pears Building to the immediate west, and fronts onto Pond Street to the north. To the south, the site lies adjacent to an existing, earlier extension undertaken to the main hospital building.

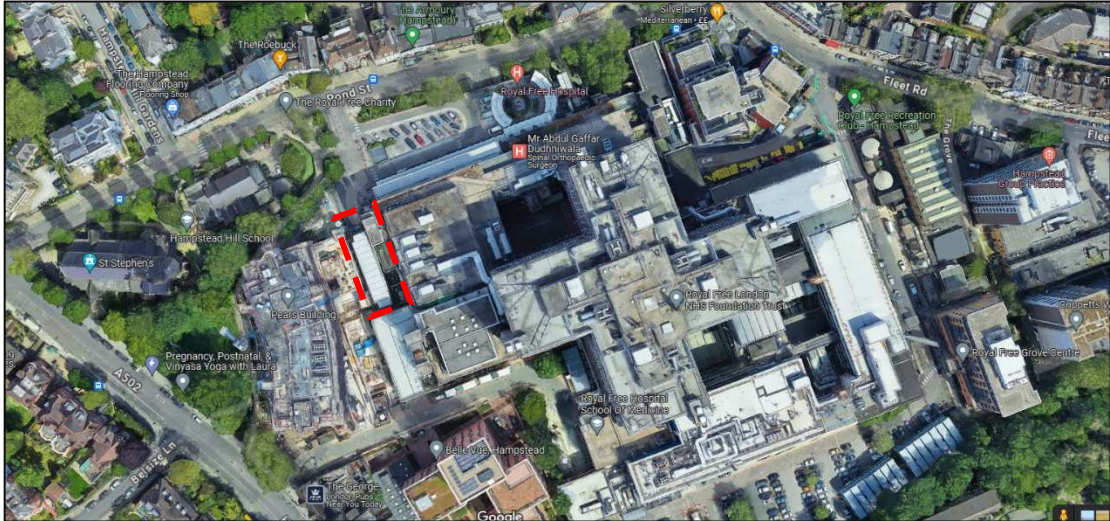


Figure 2.1 Site Location Plan (Image Source: Google Maps)

Initial inspection of the site revealed that the background noise profile at the monitoring location was dominated by existing plant noise from installations on the site.

2.2 Environmental Noise Survey Procedure

Continuous automated monitoring was undertaken for the duration of the noise survey between 12/06/2024 at 10:56 and 14/06/2024 at 14:15.

The environmental noise measurement position, proposed plant installation locations, and the closest noise sensitive receiver relative to the plant installations are described within Table 2.1 and shown within Figure 2.2.

Icon	Descriptor	Location Description
①	Noise Measurement Position 1	The microphone was installed on a pole extended approx. 2 metres from the west facade of the roof of the existing building, near the east point of the proposed new building sections, as shown in Figure 2.2 to 2.4. The microphone was positioned within free-field conditions at least 1.5 metres from the nearest surface.
②	Noise Measurement Position 2 (By Others)	Noise measurement has also been carried out by RSK Acoustics, who measured close to the nearest residential receiver, under conditions representative of the noise environment of that receiver. This position is shown in Figure 2.3, and discussed in detail in RSK Acoustics report reference '206/0904/R2/O', dated 12 April 2022.
●	Nearest noise sensitive receptors (NSRs)	West windows of the operating theatres and wards/bays on the floor below the proposed plant, floor L03.



Icon	Descriptor	Location Description
	Nearest noise sensitive, residential receptors (NSRRs)	South, residential windows of 19 Pond Street.
	Proposed plant installation location	Proposed plant installations are outlined in Section 5.1. The proposed plant covers an area of the roof/L04/L05, so the point shown in Figures 2.2 to 2.4 is in the approximate centre of the proposed area.

Table 2.1 Measurement positions and descriptions

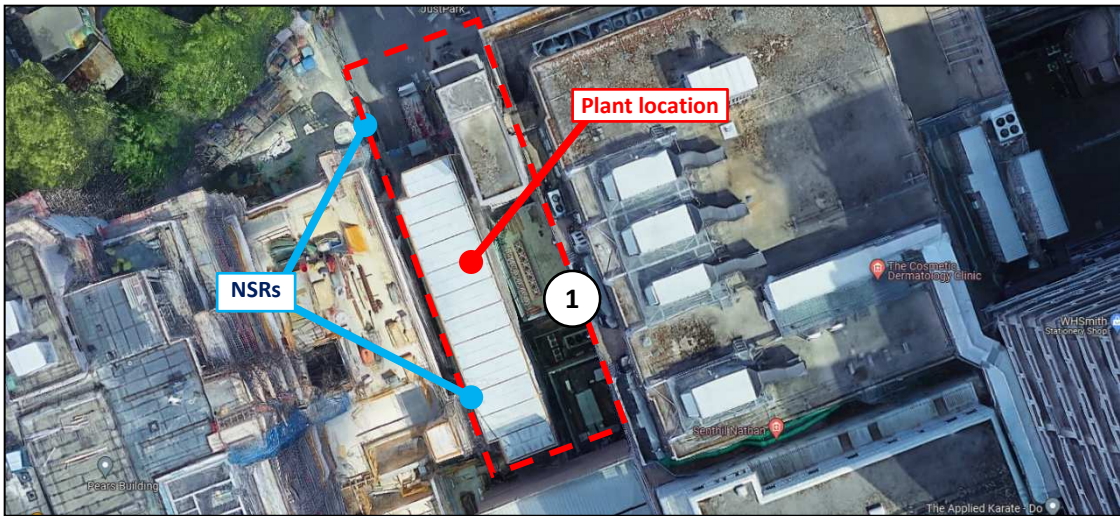


Figure 2.2 Site measurement positions, nearest receivers and proposed plant positions (Image Source: Google Maps)

The choice of the position was based both on accessibility and on collecting representative noise data in relation to the nearest noise sensitive receiver and the proposed plant installation.

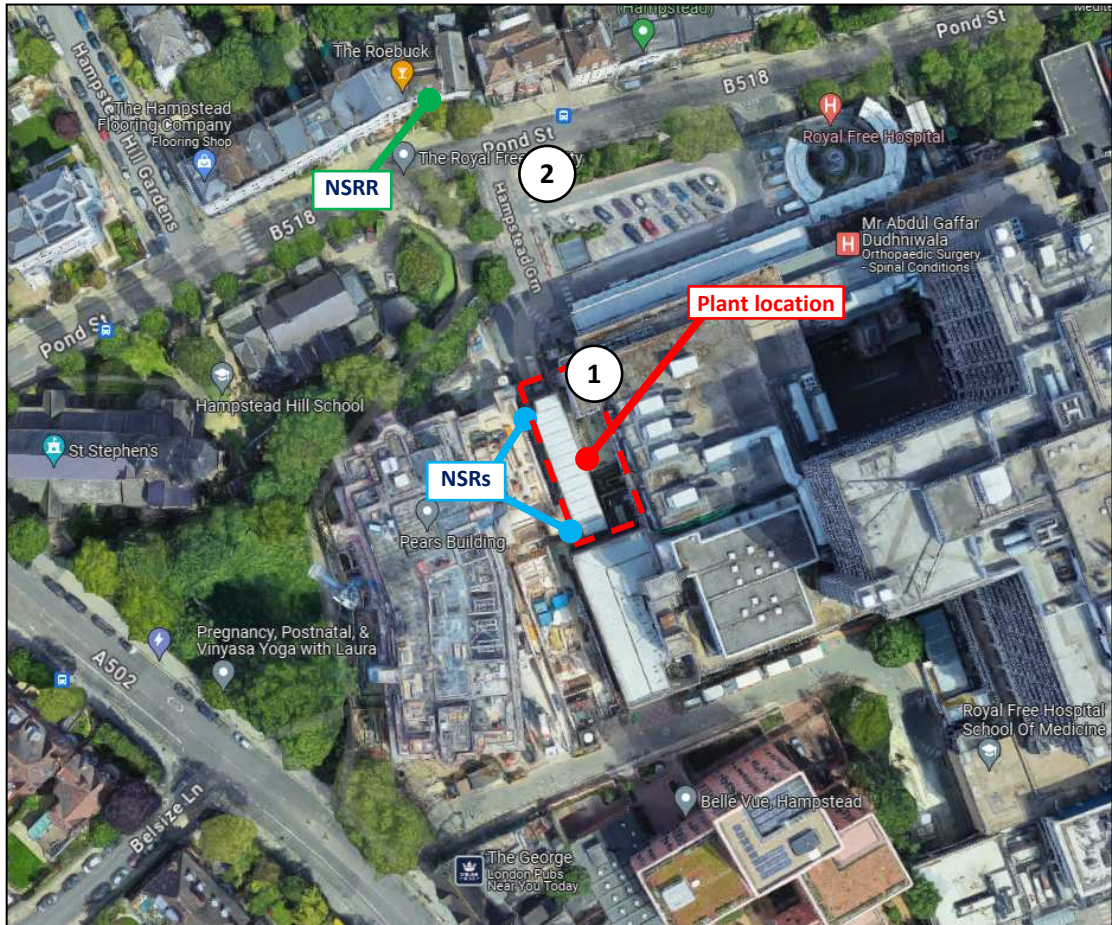


Figure 2.3 Site measurement positions, nearest residential receivers and proposed plant positions (Image Source: Google Maps)

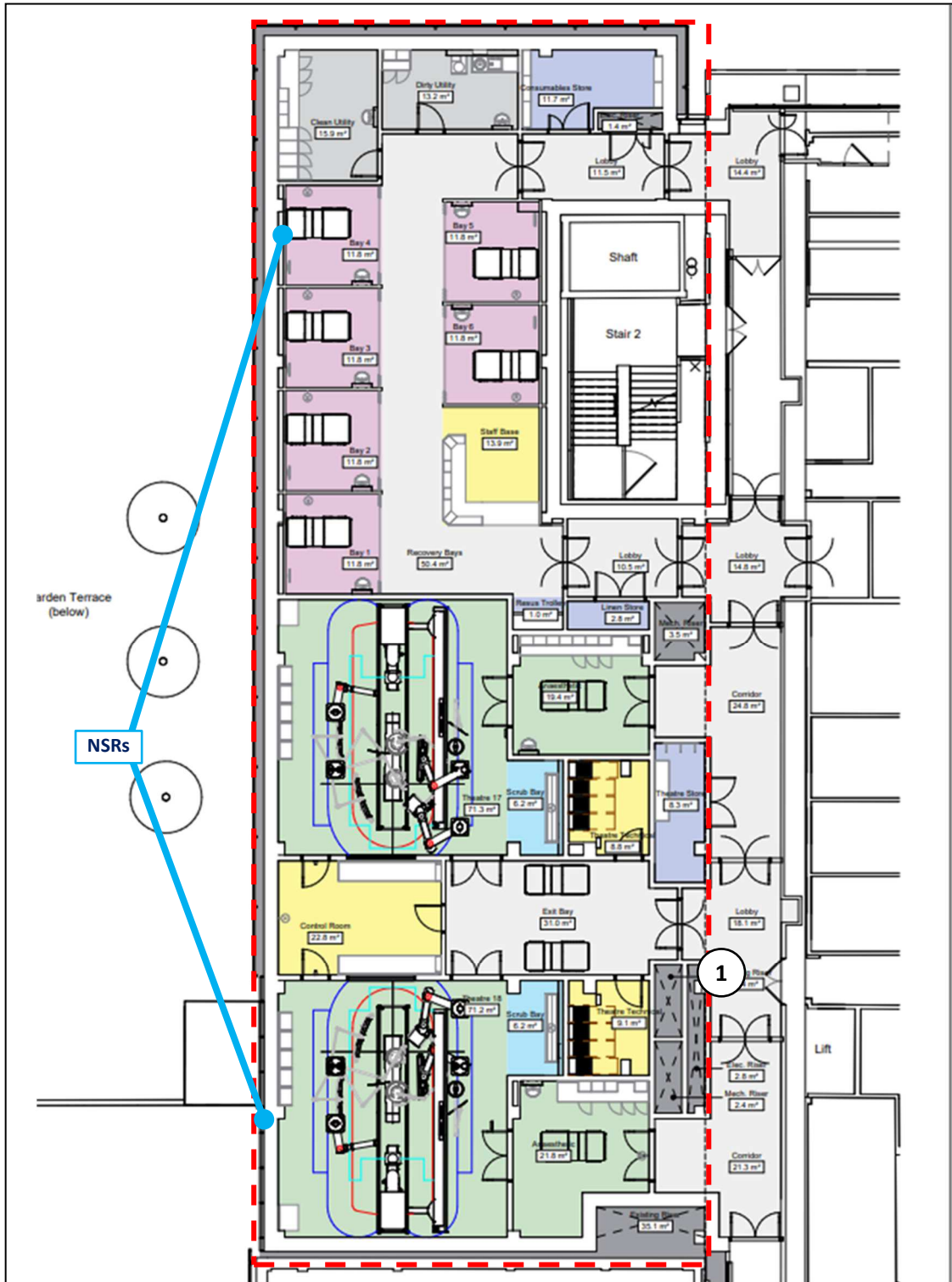


Figure 2.4 Site measurement positions, nearest receivers (Image Source: HazleMcCormackYoung LLP)

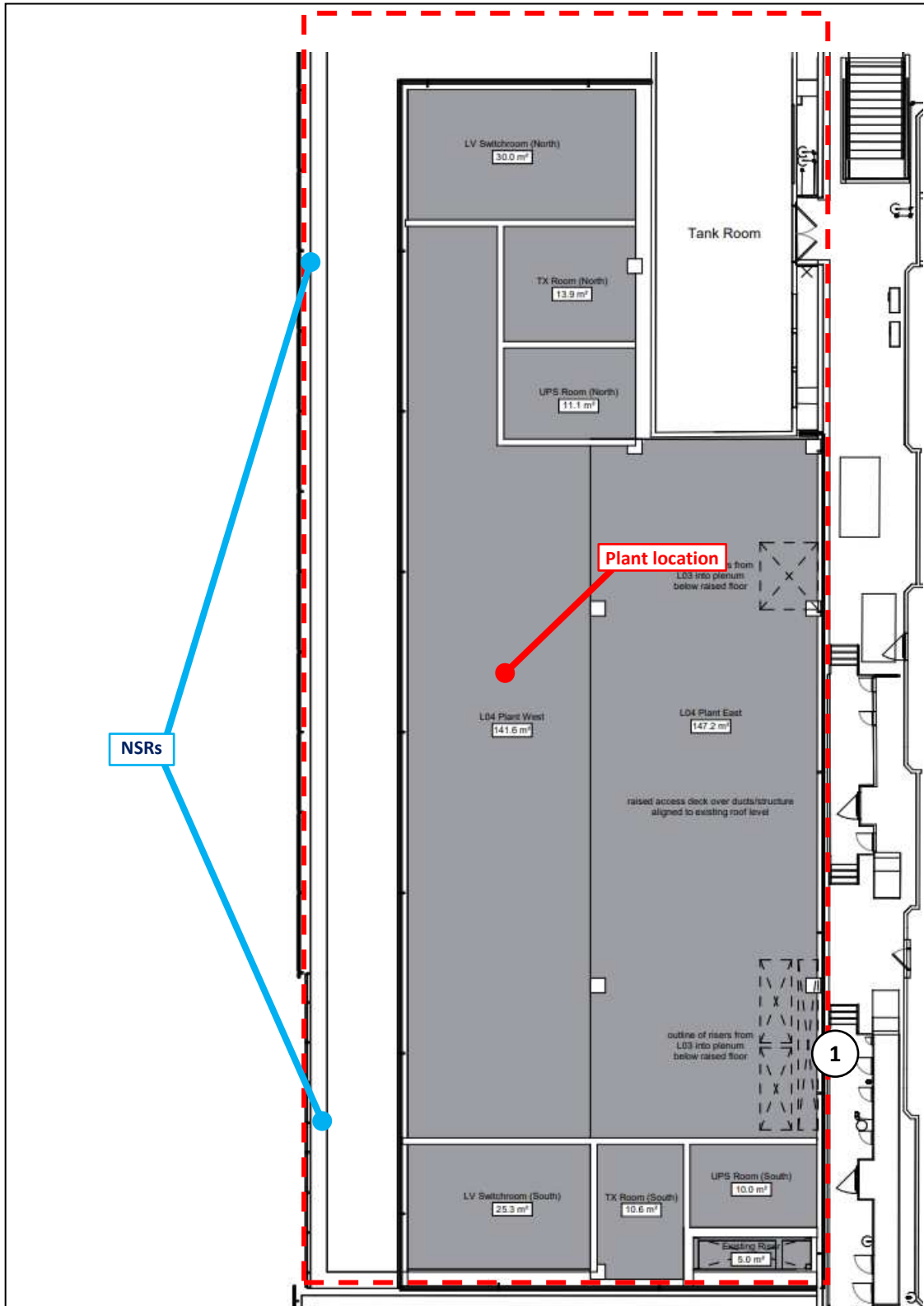


Figure 2.5 Site measurement positions, nearest receivers and proposed plant positions (Image Source: HazleMcCormackYoung LLP)

Weather conditions were generally dry with light winds and therefore suitable for the measurement of environmental noise. The measurement procedure complied with ISO 1996-

2:2017 Acoustics ‘Description, measurement and assessment of environmental noise - Part 2: Determination of environmental noise levels’.

2.3 Equipment

The equipment calibration was verified before and after use and no abnormalities were observed. The equipment used is described within Table 2.2.

Measurement instrumentation		Serial no.	Date	Cert no.
Noise Kit 26	NTI Audio XL2 Class 1 Sound Level Meter	A2A-21130-E0	21/07/2022	UK-22-067
	Free-field microphone NTI Acoustics MC230A	A23541		
	Preamp NTI Acoustics MA220	11023		
	NTI Audio External Weatherproof Shroud	-	-	-
Noise Kit 27	NTI Audio XL2 Class 1 Sound Level Meter	A2A-21174-E0	21/07/2022	UK-22-070
	Free-field microphone NTI Acoustics MC230A	A23539		
	Preamp NTI Acoustics MA220	11025		
	NTI Audio External Weatherproof Shroud	-	-	-
B&K Type 4231 Class 1 Calibrator		2147411	14/06/2024	UKAS24/06 438

Table 2.2 Measurement instrumentation

3.0 RESULTS

The $L_{Aeq: 5min}$, $L_{Amax: 5min}$, $L_{A10: 5min}$ and $L_{A90: 5min}$ acoustic parameters were measured throughout the duration of the survey. Measured levels are shown as a time history in Figure 27942.TH1-2.

Representative background noise levels are shown in Table 3.1 for daytime and night-time.

It should be noted that the representative background noise level has been derived from the $L_{A90,5min}$ levels measured during the environmental noise survey undertaken on site, as shown in 27942.Daytime L90.TH1-2 and 27942.Night-time L90.TH1-2 attached, based on the guidance of BS4142 Section 8.1.4.

Time Period	Representative background noise level L_{A90} dB(A)
Daytime (07:00-23:00)	62
Night-time (23:00-07:00)	61

Table 3.1 Representative background noise levels – Measurement Position 1

Representative noise levels are also reported from the RSK Acoustics report reference ‘206/0904/R2/0’, dated 12 April 2022, shown in Table 3.2 for daytime and night-time.

Time Period	Representative background noise level L_{A90} dB(A)
Daytime (07:00-23:00)	53
Night-time (23:00-07:00)	49

Table 3.2 Representative background noise levels – Measurement Position 2 (Source: RSK Acoustics)

4.0 NOISE ASSESSMENT GUIDANCE

4.1 BS4142: 2014 ‘Methods for rating and assessing industrial and commercial sound’

British Standard BS4142:2014 ‘Methods for rating and assessing industrial and commercial sound’ describes a method for rating and assessing sound of an industrial and/or commercial nature, which includes:

- Sound from industrial and manufacturing processes
- Sound from fixed installations which comprise mechanical and electrical plant and equipment
- Sound from the loading and unloading of goods and materials at industrial and/or commercial premises, and
- Sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes.

This Standard compares the Rating Level due to the noise source/s under assessment for a one-hour period during the daytime (07:00 – 23:00 hours) and a fifteen-minute period during the night-time (23:00 – 07:00 hours) with the existing background noise level in terms of an L_{A90} when the noise source is not operating.

It should be noted that the Rating Level is the Specific Sound Level in question (L_{Aeq, T_r}), including any relevant acoustic feature corrections, as follows:

- **Tonality** – ‘For sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0dB and +6dB for tonality. Subjectively, this can

be converted to a penalty of 2dB for a tone which is just perceptible at the noise receptor, 4dB where it is clearly perceptible, and 6dB where it is highly perceptible'

- **Impulsivity** – *'A correction of up to +9dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3dB for impulsivity which is just perceptible at the noise receptor, 6dB where it is clearly perceptible, and 9dB where it is highly perceptible'*
- **Intermittency** – *'If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied'*
- **Other sound characteristics** – *'Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied'*

Once the Rating Level has been obtained, the representative background sound level is subtracted from the Rating Level to obtain an initial estimate of the impact, as follows:

- Typically, the greater this difference, the greater the magnitude of the impact
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context
- A difference of around +5 dB could be an indication of an adverse impact, depending on the context
- The lower the rating level is relative to the measured background sound level, the less likely it is that there will be an adverse impact or significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound having a low impact, depending on the context

NOTE: Adverse impacts may include but not be limited to annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact.

The initial estimate of the impact may then be modified by taking consideration of the context in which the sound occurs.

4.2 Local Authority Guidance

The guidance provided by The London Borough of Camden for noise emissions of new plant in this instance is as follows:

The noise criteria, as per the Local Plan 2017 of London Borough of Camden, British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' should be considered as the main reference document for the assessment. The resultant 'Rating Level' would be considered as follows:

Period	Assessment Location	Rating Level Acceptability Range		
		Green: noise is considered to be at an acceptable level	Amber: noise is observed to have an adverse effect level, but which may be considered acceptable when assessed in the context of other merits of the development	Red: noise is observed to have a significant adverse effect.
Daytime (7:00-23:00)	Garden used for main amenity (free field) and Outside living or dining or Bedroom window (façade)	10dB below background	9 dB below and 5dB above background	5dB above background
Night-time (23:00-7:00)	Outside bedroom window (façade)	10dB below background and no events exceeding 57dB L_{Amax}	9db below and 5dB above background or noise events between 57dB and 88dB L_{Amax}	5dB above background and/or events exceeding 88dB L_{Amax}

Table 4.1 Camden noise criteria for plant and machinery

4.3 Noise Emissions Criterion

As the proposed plant could be used at any time of the day or night, the criterion for the nearest receiver has been set as shown in Table 4.2 in order to comply with the above requirements. The context is a hospital setting, installing plant for the use of its theatres, wards etc, and the NSRs are all parts of the hospital, with sealed windows. The receivers within the hospital are already accustomed to external plant noise from parts of the hospital, as shown in the measurements undertaken as part of this assessment. For these reasons, the criterion has been proposed in the amber category, in which it is understood that noise at background level may be considered acceptable.

The criterion for the nearest residential receiver has been set in its context, further away from the plant noise of the hospital and in no control over it, in the 'green' category.

Time period	Noise Criterion at Nearest Receiver
Night-time (23:00 to 07:00)	61 dB(A)

Table 4.2 Proposed noise emissions criterion – Measurement Position 1/NSRs

Time period	Noise Criterion at Nearest Residential Receiver
Night-time (23:00 to 07:00)	39 dB(A)

Table 4.3 Proposed noise emissions criterion – Measurement Position 2/NSRRs

5.0 NOISE IMPACT ASSESSMENT

5.1 Proposed Plant Installations

It is understood that the proposed plant installation is comprised of the following units:

Moved units (from 1st floor to 4th floor)

- 2 No. Parker ICE310 Chiller Units. Duty and standby, so only one assessed. Only overall sound pressure level at 10m available from manufacturer, so spectrum adjusted from chillers with similar overall noise output shown below. These units are now being addressed through a separate planning application, but the temporary relocation of these chillers has been assessed as a 'cumulative scenario' within this report.

AHS AHUs in L04 West

- 3 No. AHS Air Handling Units (AHUs)

Existing CU Relocated From 1st Floor Plant Room to Ground Floor External - Under North of Proposed Building

- 1 No. Mitsubishi PUZ-ZM50VKA Condensers
- 1 No. Mitsubishi PUZ-ZM35VKA Condensers
- 1 No. Mitsubishi PUZ-ZM100YKA Condensers

Proposed Chiller and Air Source Heat Pumps (ASHPs) at L05 West - Above Proposed AHUs

The below units will be duty and standby to some degree, but we understand that during the summer they may all run together, so they are assessed here together.

- 1 No. Mitsubishi RHOSS TCAEQI 4180 DP1 Chiller
- 2 No. RHOSS TXAEQU 4370 ASHPs

The proposed installation location for the proposed plant will be as shown in Figures 2.2-2.4 and 5.1-5.2. Some plant is proposed to be located at roof level, some at ground and further plant at L04 behind the louvred area shown.

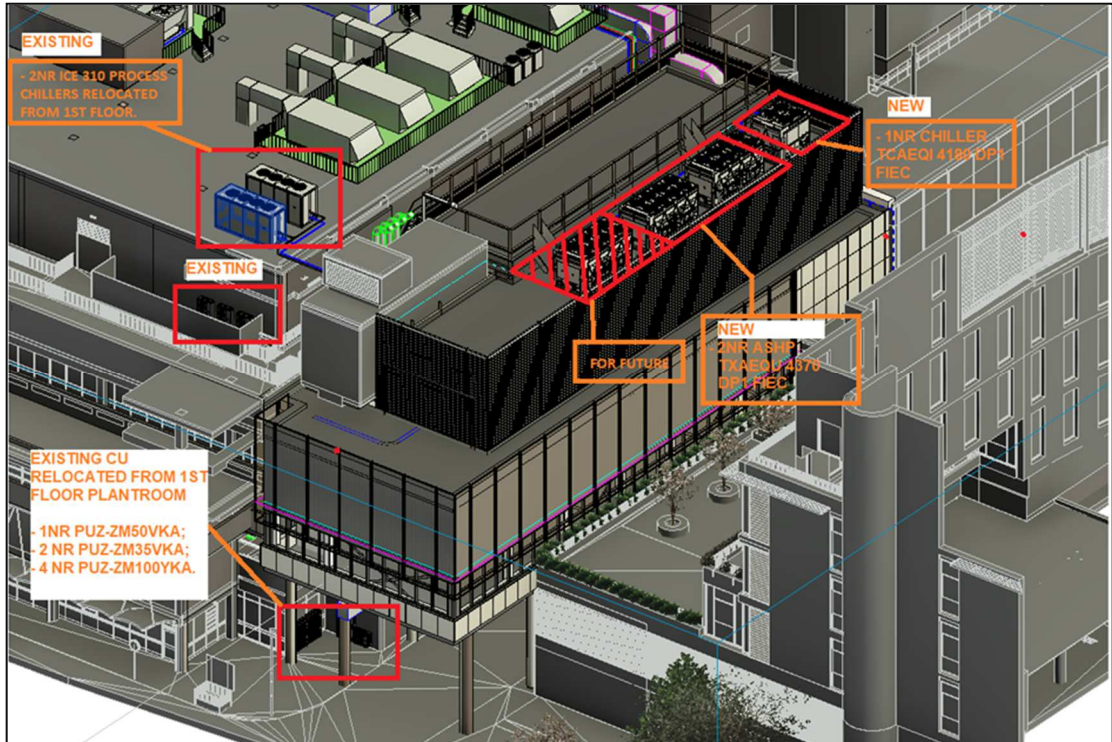


Figure 5.1 Proposed Plant 3D View (Image Source: RSP)

In Figure 5.2 below, the orientation corresponds with Figures 2.2-2.4 (northwest at top of image).

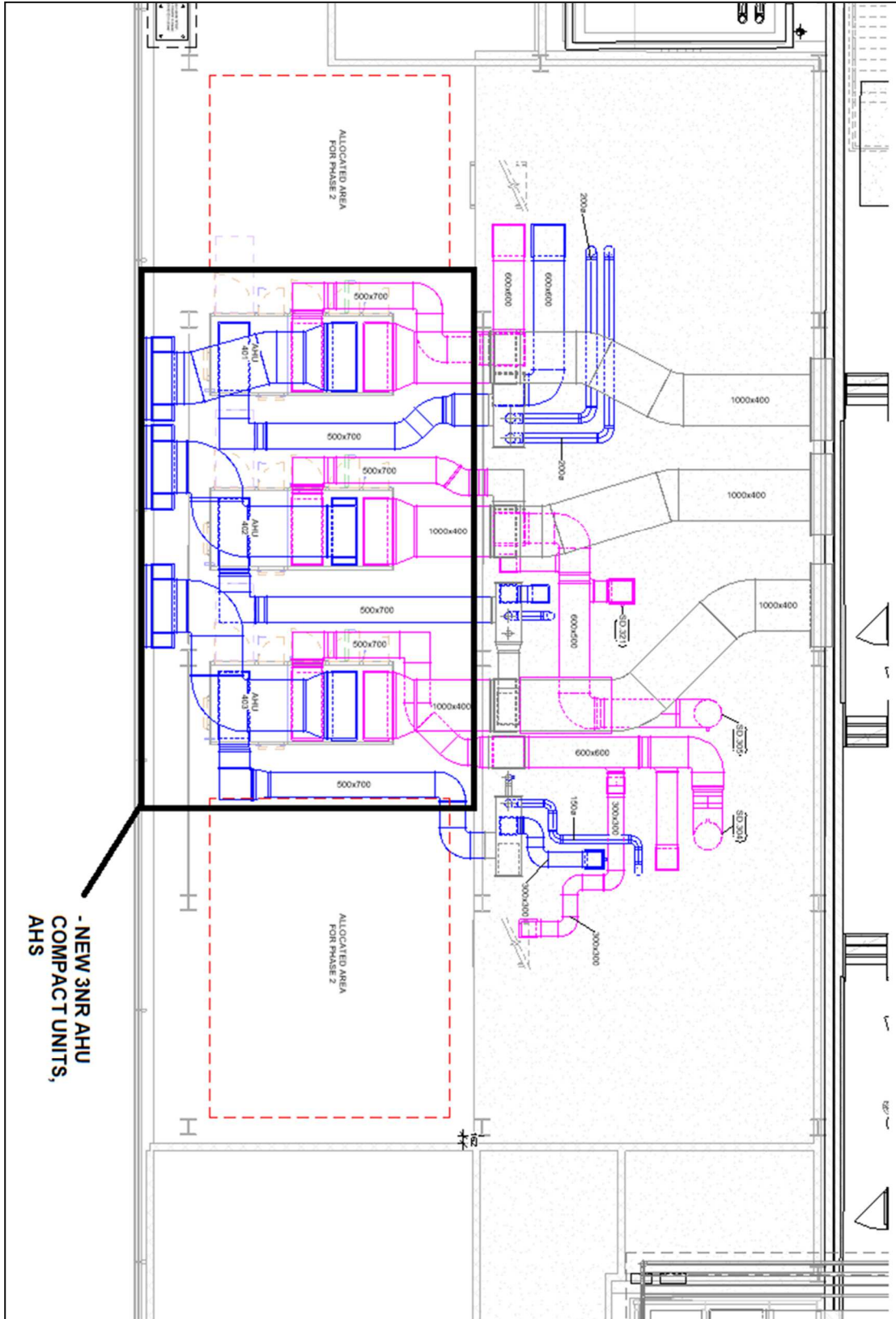


Figure 5.2 Proposed AHU Plant in L04 Plant West (Image Source: RSP)

The noise emission levels for the units as provided by the manufacturers are shown in Table 5.1.

Unit	Descriptor	Octave Frequency Band (Hz)								Overall (dBA)
		63	125	250	500	1k	2k	4k	8k	
Parker ICE310 chiller	SPL@1m (dB)	97	88	85	84	79	76	71	61	85
AHS AHU Air Exhaust Outlet	SWL (dBA)	73	73	73	72	75	77	75	70	82
AHS AHU Air Supply Inlet	SWL (dBA)	75	75	77	69	71	70	72	67	78
RHOSS TOHETL 2140	SPL@1m (dB)	75	66	57	61	51	43	36	28	60
Mitsubishi PUZ-ZM50VKA/ PUZ-ZM35VKA	SPL@1m (dB)	58	51	45	44	40	37	32	31	46
Mitsubishi PUZ-ZM100YKA	SPL@1m (dB)	54	54	53	49	46	42	36	29	51
RHOSS TCAEQI 4180 DP1	SPL@1m (dB)	76	67	64	63	58	55	50	40	64
RHOSS TXAEQU 4370 DP1	SPL@1m (dB)	85	79	66	61	59	54	50	42	67

Table 5.1 Plant Units Noise Emission Levels as provided by the manufacturer

The closest noise sensitive receivers (NSR) to the proposed installation location have been identified as the west windows of the operating theatres and wards/bays on the floor below the proposed plant, floor L03. These windows are located between 2 and 10 metres from the proposed plant installation location, depending on the position of each part, as shown in Figure 2.2. More detail for the distance of each plant section are shown in Appendix B.

The closest residential noise sensitive receiver (NSRR) to the proposed installation location has been identified as the south, residential windows of 19 Pond Street. These windows are located at least 70 metres from the proposed plant installation location, as shown in Figure 2.3.

It should be noted that the proposed plant units would be out of line of sight of the receivers due to screening from the building envelope.

5.2 Calculations

Taking all acoustic corrections into consideration, the noise level contribution expected at the closest sensitive window from the proposed plant installation would be as shown in Table 5.2. Detailed calculations are shown in Appendix B.

Receiver	Criterion, dB(A)	Noise Level at 1m From the Closest Noise Sensitive Window, dB(A)
West windows of the operating theatres and wards/bays on the floor below the proposed plant, floor L03	61	57

Table 5.2 Predicted noise level and criterion at nearest noise sensitive location

Taking all acoustic corrections into consideration, the noise level contribution expected at the closest sensitive, residential window from the proposed plant installation would be as shown in Table 5.3. Detailed calculations are shown in Appendix B.

Receiver	Criterion, dB(A)	Noise Level at 1m From the Closest Noise Sensitive Window, dB(A)
South, residential windows of 19 Pond Street	39	38

Table 5.3 Predicted noise level and criterion at nearest noise sensitive location

As shown in Appendix B and Tables 5.2 and 5.3, transmission of noise to the nearest sensitive windows, and nearest sensitive residential windows due to the effects of the proposed plant unit installation satisfies the emissions criterion of the Local Authority, providing that the mitigation measures outlined in Section 6 are implemented.

6.0 NOISE CONTROL MEASURES

In order to achieve the specific sound level and subsequent rating level shown in the assessment above, the following noise control strategy should be adopted.

6.1 In-Line Ductwork Attenuators

In order to control the noise emissions from the proposed AHUs, it is understood that the following attenuators are proposed to be installed at atmosphere side, providing the insertion loss values outlined in Table 6.1 below. These have been incorporated into the calculations discussed above, and have been found to be sufficient to control noise emissions.

Application	Insertion Loss Levels (dB) in each Octave Frequency Band							
	63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	8kHz
AHS AHU Air Exhaust Outlet	2	5	9	18	26	21	18	11
AHS AHU Air Supply Inlet	3	5	10	15	20	15	13	8

Table 6.1 Insertion loss figures to be provided by acoustic silencer

6.2 Anti-Vibration Mounting Strategy

In the case of all plant units, appropriate anti-vibration mounts should be installed in order to ensure that vibrations do not give rise to structure-borne noise. Appendix C outlines detailed advice in order to ensure that the system installer selects the appropriate anti-vibration mount for the installation.

It is the supplier's responsibility to ensure that all mountings offered are suitable for the loads, operating and environmental conditions which will prevail.

7.0 CONCLUSION

An environmental noise survey has been undertaken at Hybrid Theatres, Royal Free London, Pond Street, London, NW3 2QG by KP Acoustics Ltd between 12/06/2024 at 10:56 and 14/06/2024 at 14:15. The results of the survey have enabled criteria to be set for noise emissions.

Manufacturer’s noise data of proposed plant units has been used to obtain Specific and Rated Noise Level at the nearest noise sensitive receiver in accordance with British Standard BS4142:2014 for compliance with London Borough of Camden requirements.

The rating level was compared with the representative background noise level to assess the likelihood of impact considering the environmental noise context of the area as per the requirements of BS4142:2014.

It has been concluded that noise emissions from the proposed plant units would not have an adverse impact on the nearest sensitive receivers provided that the noise control strategy presented in Section 6 is followed.

Hybrid Theatres, Royal Free London - Position 1
Environmental Time History
12/06/2024 to 14/06/2024

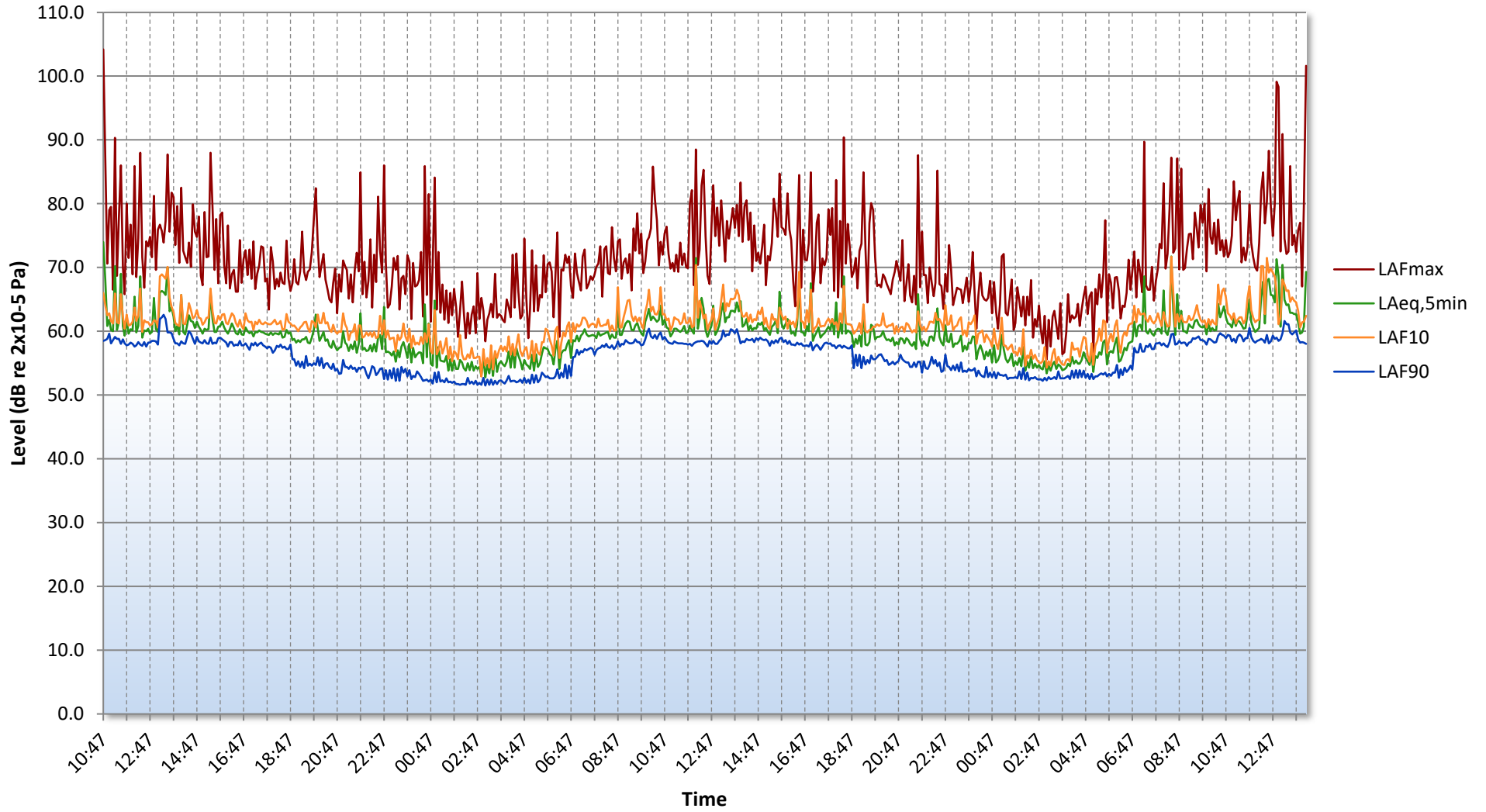


Figure 27942.TH1

Hybrid Theatres, Royal Free London - Position 1
Representative Daytime Background Noise Level
12/06/2024 to 14/06/2024

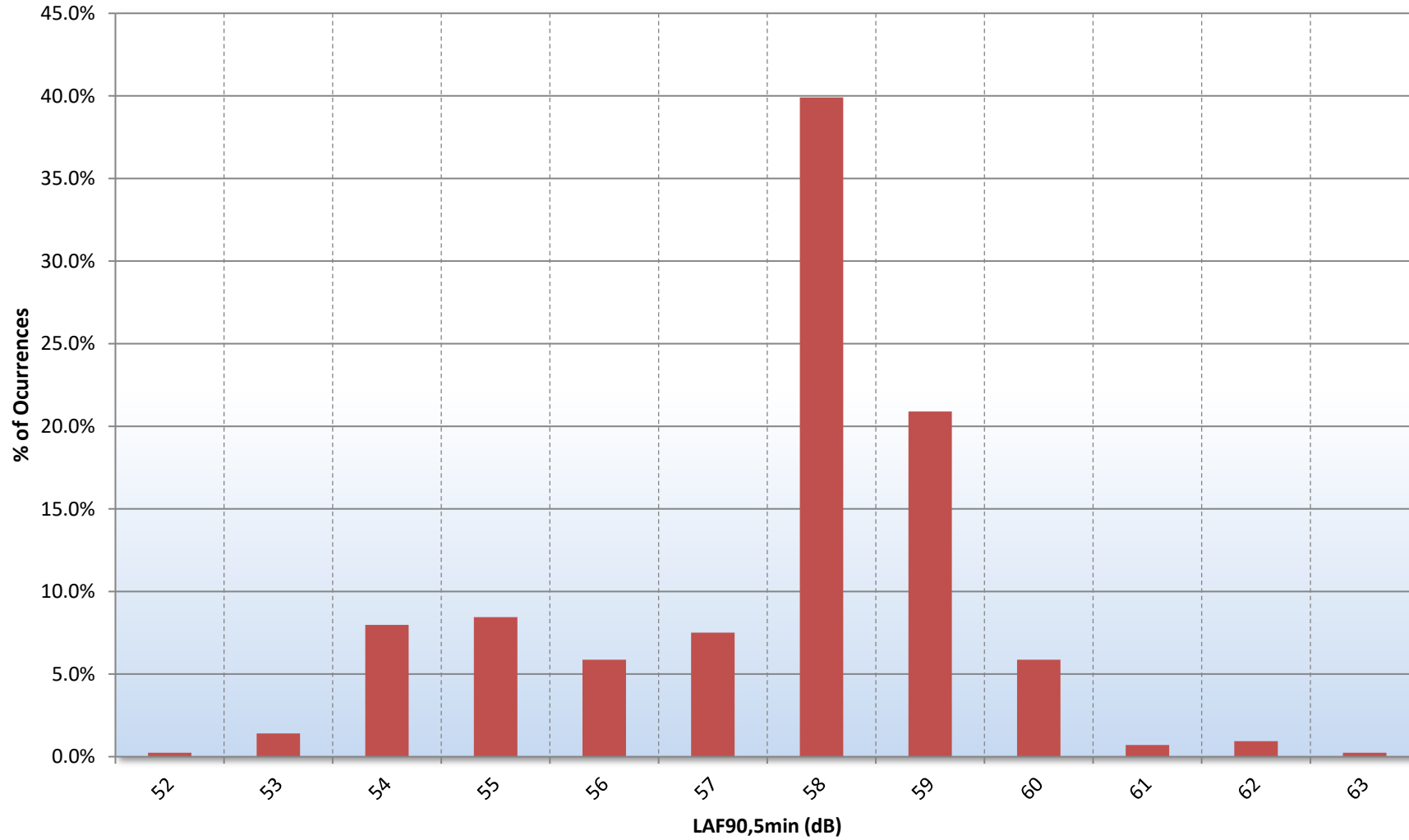


Figure 27942.Daytime L90.TH1

Hybrid Theatres, Royal Free London - Position 1
Representative Night-time Background Noise Level
12/06/2024 to 14/06/2024

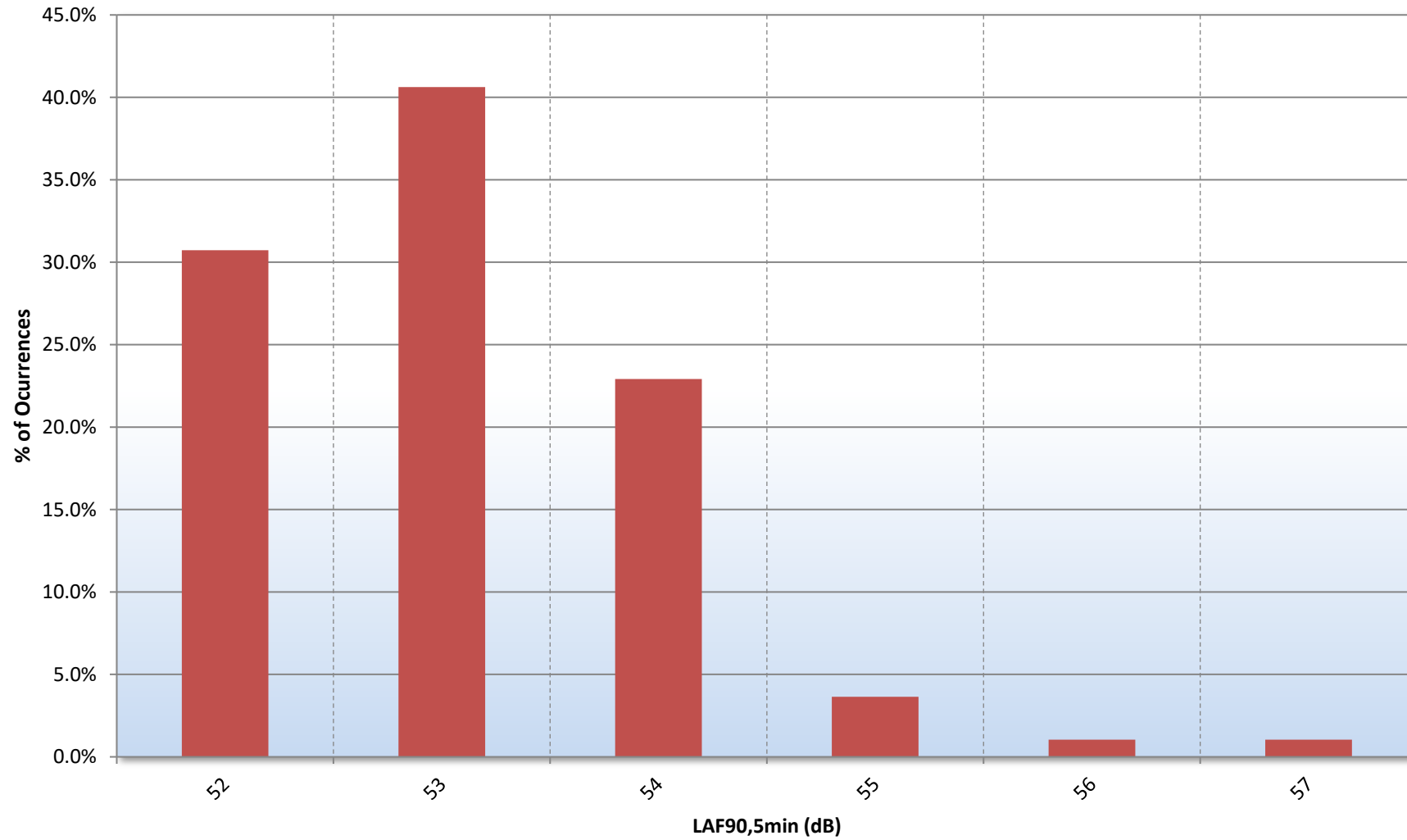


Figure 27942.Night-time L90.TH1

Hybrid Theatres, Royal Free London - Position 2
Environmental Time History
12/06/2024 to 14/06/2024

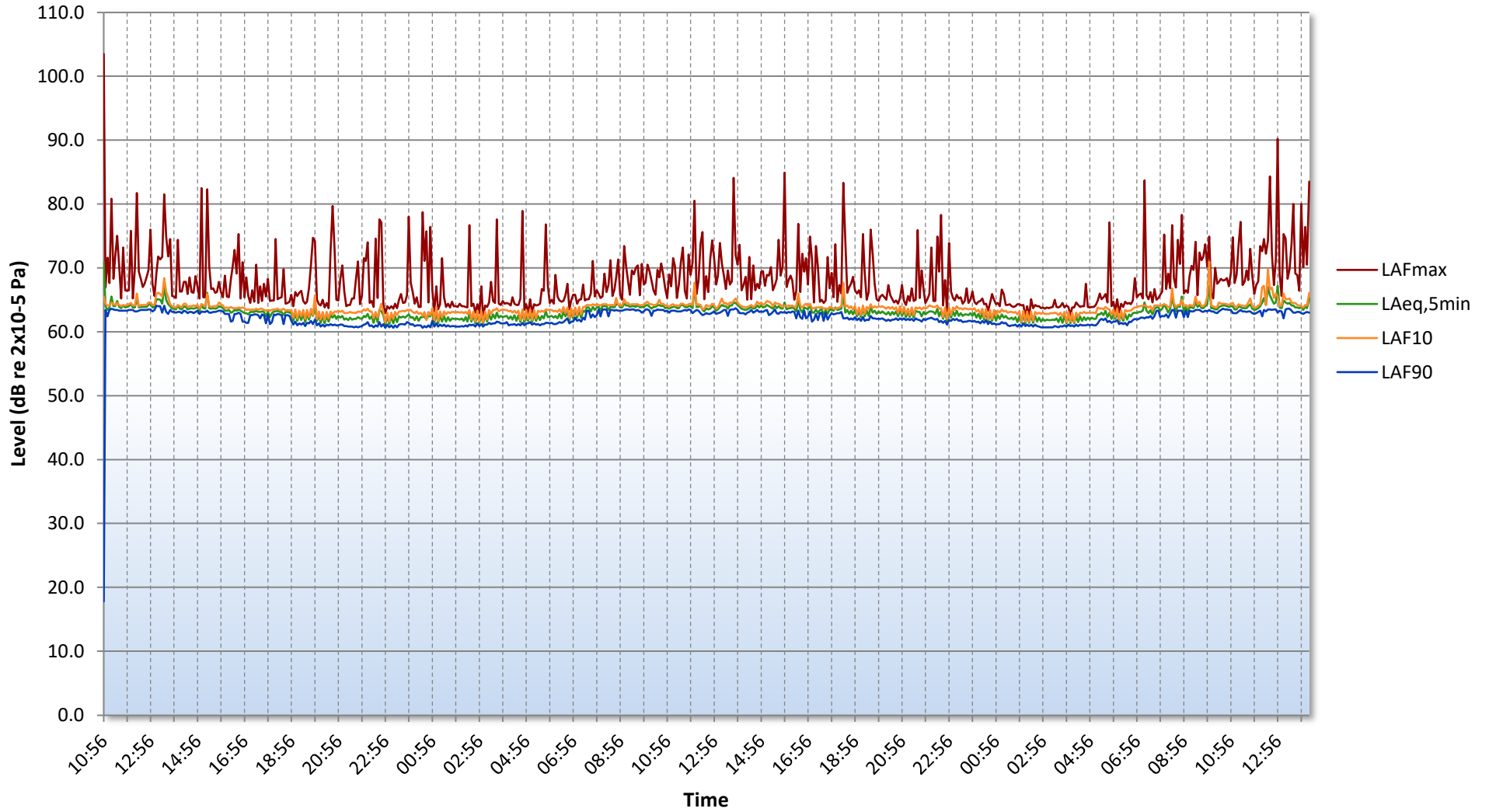


Figure 27942.TH2

Hybrid Theatres, Royal Free London - Position 2
Representative Daytime Background Noise Level
12/06/2024 to 14/06/2024

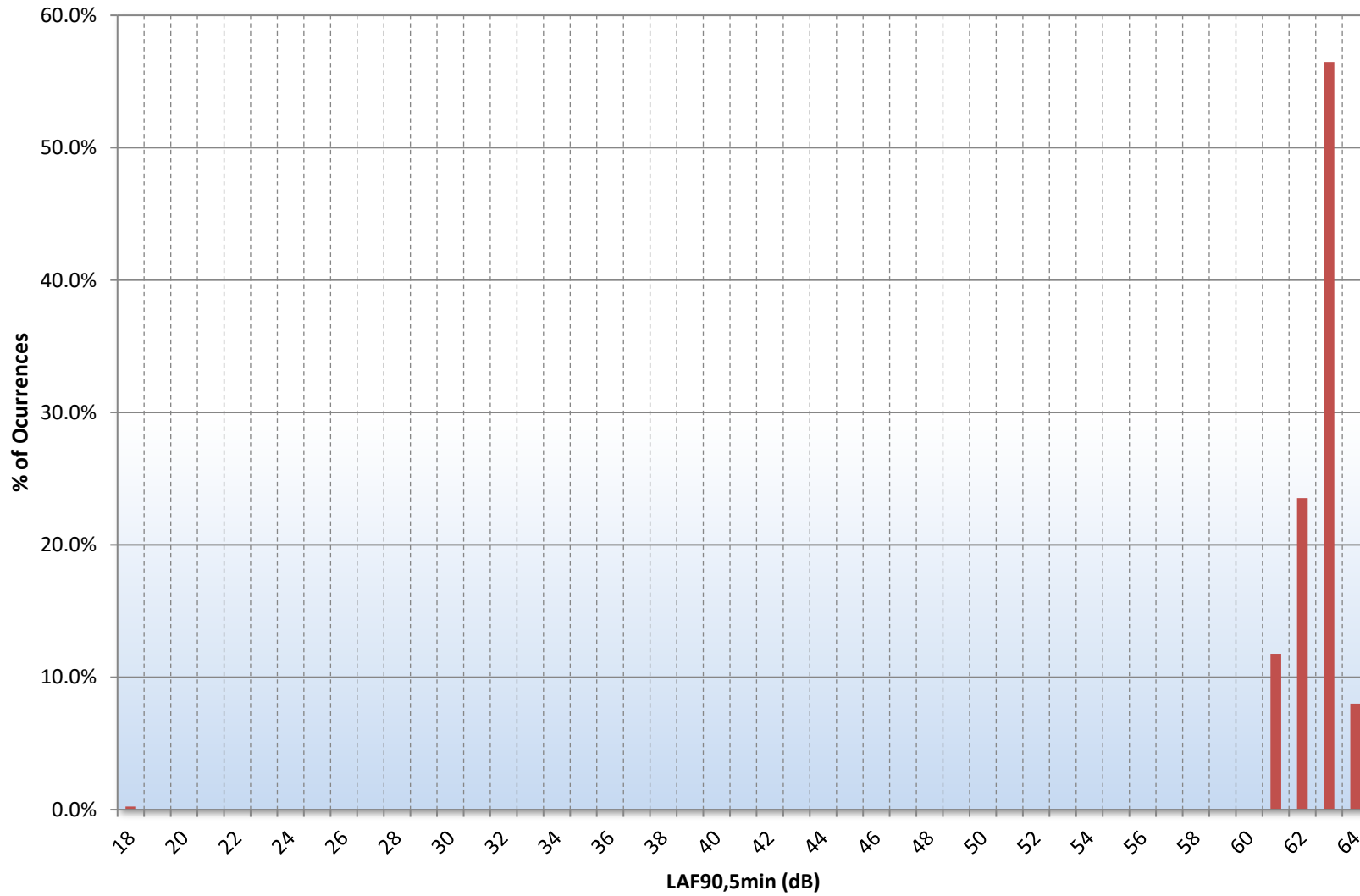


Figure 27042 Daytime L90 TH2

Hybrid Theatres, Royal Free London - Position 2
Representative Night-time Background Noise Level
12/06/2024 to 14/06/2024

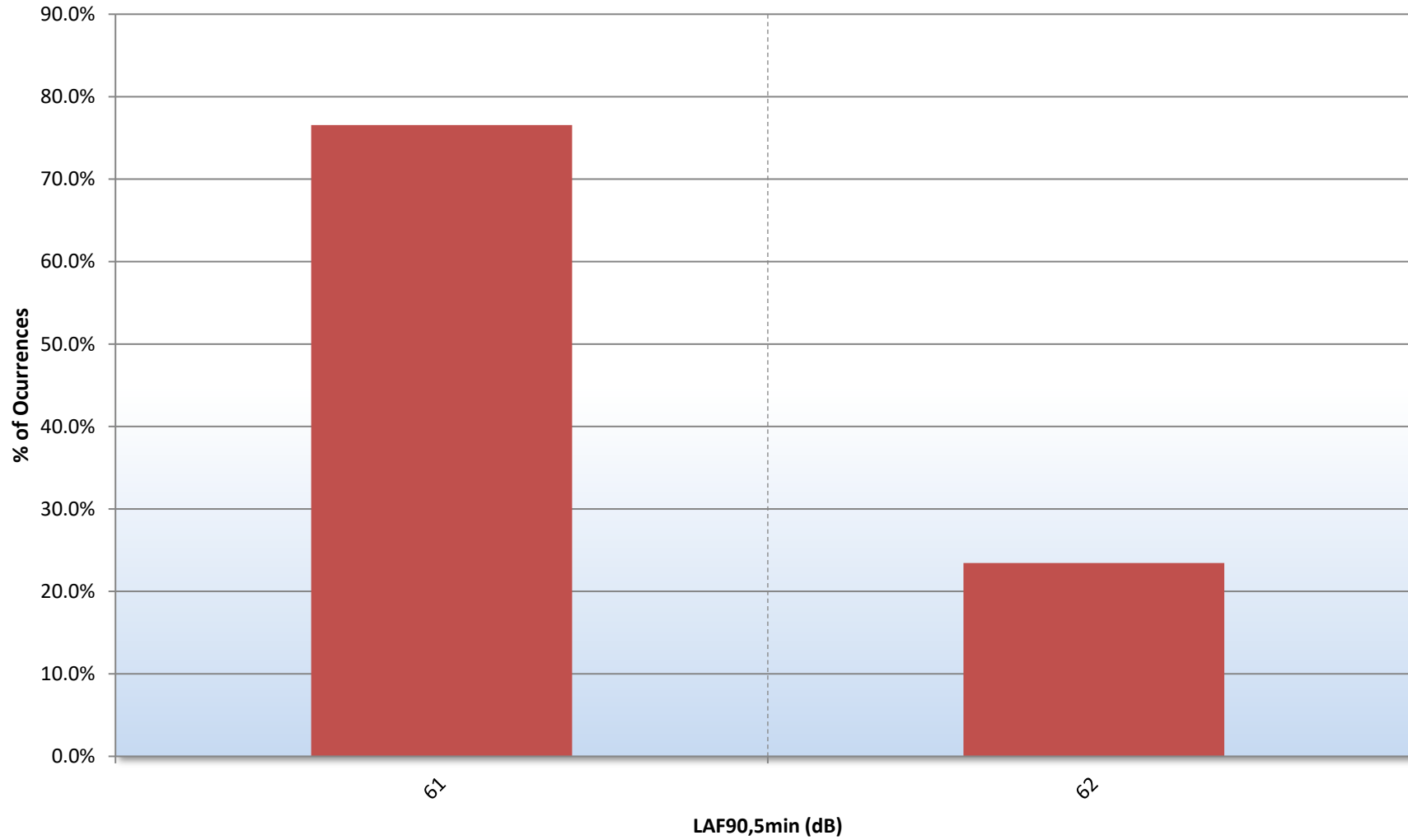


Figure 27942.Night-time L90.TH2

GENERAL ACOUSTIC TERMINOLOGY

Decibel scale - dB

In practice, when sound intensity or sound pressure is measured, a logarithmic scale is used in which the unit is the 'decibel', dB. This is derived from the human auditory system, where the dynamic range of human hearing is so large, in the order of 10^{13} units, that only a logarithmic scale is the sensible solution for displaying such a range.

Decibel scale, 'A' weighted - dB(A)

The human ear is less sensitive at frequency extremes, below 125Hz and above 16Khz. A sound level meter models the ears variable sensitivity to sound at different frequencies. This is achieved by building a filter into the Sound Level Meter with a similar frequency response to that of the ear, an A-weighted filter where the unit is dB(A).

L_{eq}

The sound from noise sources often fluctuates widely during a given period of time. An average value can be measured, the equivalent sound pressure level L_{eq} . The L_{eq} is the equivalent sound level which would deliver the same sound energy as the actual fluctuating sound measured in the same time period.

L_{10}

This is the level exceeded for no more than 10% of the time. This parameter is often used as a "not to exceed" criterion for noise.

L_{90}

This is the level exceeded for no more than 90% of the time. This parameter is often used as a descriptor of "background noise" for environmental impact studies.

L_{max}

This is the maximum sound pressure level that has been measured over a period.

Octave Bands

In order to completely determine the composition of a sound it is necessary to determine the sound level at each frequency individually. Usually, values are stated in octave bands. The audible frequency region is divided into 11 such octave bands whose centre frequencies are defined in accordance with international standards. These centre frequencies are: 16, 31.5, 63, 125, 250, 500, 1000, 2000, 4000, 8000 and 16000 Hertz.

Environmental noise terms are defined in BS7445, *Description and Measurement of Environmental Noise*.

APPLIED ACOUSTIC TERMINOLOGY

Addition of noise from several sources

Noise from different sound sources combines to produce a sound level higher than that from any individual source. Two equally intense sound sources operating together produce a sound level which is 3dB higher than a single source and 4 sources produce a 6dB higher sound level.

Attenuation by distance

Sound which propagates from a point source in free air attenuates by 6dB for each doubling of distance from the noise source. Sound energy from line sources (e.g. stream of cars) drops off by 3dB for each doubling of distance.

Subjective impression of noise

Hearing perception is highly individualised. Sensitivity to noise also depends on frequency content, time of occurrence, duration of sound and psychological factors such as emotion and expectations. The following table is a guide to explain increases or decreases in sound levels for many scenarios.

Change in sound level (dB)	Change in perceived loudness
1	Imperceptible
3	Just barely perceptible
6	Clearly noticeable
10	About twice as loud

Transmission path(s)

The transmission path is the path the sound takes from the source to the receiver. Where multiple paths exist in parallel, the reduction in each path should be calculated and summed at the receiving point. Outdoor barriers can block transmission paths, for example traffic noise. The effectiveness of barriers is dependent on factors such as its distance from the noise source and the receiver, its height and construction.

Ground-borne vibration

In addition to airborne noise levels caused by transportation, construction, and industrial sources there is also the generation of ground-borne vibration to consider. This can lead to structure-borne noise, perceptible vibration, or in rare cases, building damage.

Sound insulation - Absorption within porous materials

Upon encountering a porous material, sound energy is absorbed. Porous materials which are intended to absorb sound are known as absorbents, and usually absorb 50 to 90% of the energy and are frequency dependent. Some are designed to absorb low frequencies, some for high frequencies and more exotic designs being able to absorb very wide ranges of frequencies. The energy is converted into both mechanical movement and heat within the material; both the stiffness and mass of panels affect the sound insulation performance.

APPENDIX B

Hybrid Theatres, Royal Free London, Pond Street, London

PLANT NOISE EMISSIONS CALCULATIONS

Source: Proposed plant at the proposed new building at Hybrid Theatres, Royal Free London Receiver: West windows of the operating theatres and wards/bays on the floor below the proposed plant, floor L03	Frequency, Hz								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Moved units (from 1st floor to 4th floor)									
Parker ICE310 chiller (Sound Pressure Level @1m)	97	88	85	84	79	76	71	61	85
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-7	-9	-11	-14	-17	-21	-25	-25	
Minimum attenuation provided by distance (10m), dB	-20	-20	-20	-20	-20	-20	-20	-20	
Total Noise Emissions from Above Units, dB	72	62	57	53	45	38	29	19	54
AHS AHUs in L04 West									
Air Handling Unit - Noise Emissions from Air Exhaust Outlet									
AHS AHU (Sound Power Level)	73	73	73	72	75	77	75	70	82
Correction for number of units (3),dB	5	5	5	5	5	5	5	5	
Attenuation due to duct length (6m), dB	0	0	0	0	0	0	0	0	
Attenuation due to duct bends (2), dB	-16	-8	-2	0	0	0	0	0	
Correction due to duct end reflection, dB	-8	-4	-1	0	0	0	0	0	
Conversion to SPL@1m	-11	-11	-11	-11	-11	-11	-11	-11	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Directivity correction, dB	3	3	3	3	-3	-11	-11	-11	
Minimum attenuation provided by the building envelope, dB	-5	-6	-6	-7	-9	-12	-16	-20	
Minimum attenuation provided by distance (2m), dB	-6	-6	-6	-6	-6	-6	-6	-6	
Minimum attenuation required from proposed attenuator, dB	-2	-5	-9	-18	-26	-21	-18	-11	
Total Noise Emissions from Air Handling Unit Air Exhaust Outlet, dB	36	44	48	40	28	24	21	19	42
Air Handling Unit - Noise Emissions from Air Supply Inlet									
AHS AHU (Sound Power Level)	75	75	77	69	71	70	72	67	78
Correction for number of units (3),dB	5	5	5	5	5	5	5	5	
Attenuation due to duct length (6m), dB	0	0	0	0	0	0	0	0	
Attenuation due to duct bends (2), dB	-16	-8	-2	0	0	0	0	0	
Correction due to duct end reflection, dB	-8	-4	-1	0	0	0	0	0	
Conversion to SPL@1m	-11	-11	-11	-11	-11	-11	-11	-11	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Directivity correction, dB	3	3	3	3	-3	-11	-11	-11	
Minimum attenuation provided by the building envelope, dB	-5	-6	-6	-7	-9	-12	-16	-20	
Minimum attenuation provided by distance (2m), dB	-6	-6	-6	-6	-6	-6	-6	-6	
Minimum attenuation required from proposed attenuator, dB	-3	-5	-10	-15	-20	-15	-13	-8	
Total Noise Emissions from Air Handling Unit Air Supply Inlet, dB	37	46	51	40	30	23	23	19	44
Flow Boosters in L04 East									
RHOSS TOHETL 2140 (Sound Pressure Level @1m)	75	66	57	61	51	43	36	28	60
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-7	-9	-11	-14	-17	-21	-25	-25	
Minimum attenuation provided by distance (6m), dB	-16	-16	-16	-16	-16	-16	-16	-16	
Total Noise Emissions from Above Units, dB	58	47	36	38	24	12	1	-7	38
Existing CU relocated from 1st floor plant room to ground floor external - under north of proposed building									
Mitsubishi PUZ-ZM50VKA (Sound Pressure Level @1m)	58	51	45	44	40	37	32	31	46
Correction due to surface reflections (2), dB	6	6	6	6	6	6	6	6	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (3m), dB	-10	-10	-10	-10	-10	-10	-10	-10	
Total Noise Emissions from Above Units, dB	49	42	35	33	27	21	11	7	34
Mitsubishi PUZ-ZM35VKA (Sound Pressure Level @1m)	58	51	45	44	40	37	32	31	46
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (2), dB	6	6	6	6	6	6	6	6	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (3m), dB	-10	-10	-10	-10	-10	-10	-10	-10	
Total Noise Emissions from Above Units, dB	52	45	38	36	30	24	14	10	37

Mitsubishi PUZ-ZM100YKA (Sound Pressure Level @1m)	54	54	53	49	46	42	36	29	51
Correction for number of units (4),dB	6	6	6	6	6	6	6	6	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (3m), dB	-10	-10	-10	-10	-10	-10	-10	-10	
Total Noise Emissions from Above Units, dB	48	48	46	41	36	29	18	8	43
Proposed Chiller and ASHPs at L05 West - Above Proposed AHUs									
RHOSS TCAEQI 4180 DP1 (Sound Pressure Level @1m)	76	67	64	63	58	55	50	40	64
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (6m), dB	-16	-16	-16	-16	-16	-16	-16	-16	
Total Noise Emissions from Above Units, dB	58	49	45	43	36	29	20	6	43
RHOSS TXAEQU 4370 DP1 (Sound Pressure Level @1m)	85	79	66	61	59	54	50	42	67
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (6m), dB	-16	-16	-16	-16	-16	-16	-16	-16	
Total Noise Emissions from Above Units, dB	70	64	50	44	40	31	23	12	51
Sound Pressure Level at Receiver due to All Units, dB	75	66	59	55	47	40	32	24	57

Design Criterion	61
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APPENDIX B2

Hybrid Theatres, Royal Free London, Pond Street, London

PLANT NOISE EMISSIONS CALCULATIONS

Source: Proposed plant at the proposed new building at Hybrid Theatres, Royal Free London Receiver (NSRR): South, residential windows of 19 Pond Street	Frequency, Hz								dB(A)
	63	125	250	500	1k	2k	4k	8k	
Moved units (from 1st floor to 4th floor)									
Parker ICE310 chiller (Sound Pressure Level @1m)	97	88	85	84	79	76	71	61	85
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-7	-9	-11	-14	-17	-21	-25	-25	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	55	45	40	36	28	21	12	2	38
AHS AHUs in L04 West									
Air Handling Unit - Noise Emissions from Air Exhaust Outlet									
AHS AHU (Sound Power Level)	73	73	73	72	75	77	75	70	82
Correction for number of units (3),dB	5	5	5	5	5	5	5	5	
Attenuation due to duct length (6m), dB	0	0	0	0	0	0	0	0	
Attenuation due to duct bends (2), dB	-16	-8	-2	0	0	0	0	0	
Correction due to duct end reflection, dB	-8	-4	-1	0	0	0	0	0	
Conversion to SPL@1m	-11	-11	-11	-11	-11	-11	-11	-11	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Directivity correction, dB	3	3	3	3	-3	-11	-11	-11	
Minimum attenuation provided by the building envelope, dB	-5	-6	-6	-7	-9	-12	-16	-20	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Minimum attenuation required from proposed attenuator, dB	-2	-5	-9	-18	-26	-21	-18	-11	
Total Noise Emissions from Air Handling Unit Air Exhaust Outlet, dB	5	13	17	9	-3	-7	-10	-12	11
Air Handling Unit - Noise Emissions from Air Supply Inlet									
AHS AHU (Sound Power Level)	75	75	77	69	71	70	72	67	78
Correction for number of units (3),dB	5	5	5	5	5	5	5	5	
Attenuation due to duct length (6m), dB	0	0	0	0	0	0	0	0	
Attenuation due to duct bends (2), dB	-16	-8	-2	0	0	0	0	0	
Correction due to duct end reflection, dB	-8	-4	-1	0	0	0	0	0	
Conversion to SPL@1m	-11	-11	-11	-11	-11	-11	-11	-11	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Directivity correction, dB	3	3	3	3	-3	-11	-11	-11	
Minimum attenuation provided by the building envelope, dB	-5	-6	-6	-7	-9	-12	-16	-20	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Minimum attenuation required from proposed attenuator, dB	-3	-5	-10	-15	-20	-15	-13	-8	
Total Noise Emissions from Air Handling Unit Air Supply Inlet, dB	6	15	20	9	-1	-8	-8	-12	13
Flow Boosters in L04 East									
RHOSS TOHETL 2140 (Sound Pressure Level @1m)	75	66	57	61	51	43	36	28	60
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-7	-9	-11	-14	-17	-21	-25	-25	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	37	26	15	16	3	-9	-20	-28	17
Existing CU relocated from 1st floor plant room to ground floor external - under north of proposed building									
Mitsubishi PUZ-ZM50VKA (Sound Pressure Level @1m)	58	51	45	44	40	37	32	31	46
Correction due to surface reflections (2), dB	6	6	6	6	6	6	6	6	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	22	14	8	6	-1	-7	-16	-21	7
Mitsubishi PUZ-ZM35VKA (Sound Pressure Level @1m)	58	51	45	44	40	37	32	31	46
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (2), dB	6	6	6	6	6	6	6	6	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	25	17	11	9	2	-4	-13	-18	10

Mitsubishi PUZ-ZM100YKA (Sound Pressure Level @1m)	54	54	53	49	46	42	36	29	51
Correction for number of units (4),dB	6	6	6	6	6	6	6	6	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	21	21	19	14	8	1	-9	-20	15
Proposed Chiller and ASHPs at L05 West - Above Proposed AHUs									
RHOSS TCAEQI 4180 DP1 (Sound Pressure Level @1m)	76	67	64	63	58	55	50	40	64
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	37	27	23	21	14	8	-1	-15	22
RHOSS TXAEQU 4370 DP1 (Sound Pressure Level @1m)	85	79	66	61	59	54	50	42	67
Correction for number of units (2),dB	3	3	3	3	3	3	3	3	
Correction due to surface reflections (1), dB	3	3	3	3	3	3	3	3	
Minimum attenuation due to building envelope, dB	-5	-6	-6	-8	-10	-13	-17	-21	
Minimum attenuation provided by distance (70m), dB	-37	-37	-37	-37	-37	-37	-37	-37	
Total Noise Emissions from Above Units, dB	49	42	29	22	18	10	2	-10	29
Sound Pressure Level at Receiver due to All Units, dB	56	47	40	37	29	21	13	3	38

Design Criterion	39
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ANTI-VIBRATION MOUNTING SPECIFICATION REFERENCE DOCUMENT

1.0 General

- 1.1 All mountings shall provide the static deflection, under the equipment weight, shown in the schedules. Mounting selection should allow for any eccentric load distribution or torque reaction, so that the design deflection is achieved on all mountings under the equipment, under operating conditions.
- 1.2 It is the supplier's responsibility to ensure that all mountings offered are suitable for the loads, operating and environmental conditions which will prevail. Particular attention should be paid to mountings which will be exposed to atmospheric conditions to prevent corrosion.
- 1.3 All mountings shall be colour coded, or otherwise marked, to indicate their load capacity, to facilitate identification during installation.

Where use of resilient supports allows omission of pipe flexible connections for vibration/noise isolation, it shall be the Mechanical Service Consultant's or Contractor's responsibility to decide whether such devices are required to compensate for misalignment or thermal strain.

2.1 Type A Mounting (Caged Spring Type)

- 2.1.1 Each mounting shall consist of cast or fabricated telescopic top and bottom housings enclosing one or more helical steel springs as the principle isolation elements, and shall incorporate a built-in levelling device. The housing should be designed to permit visual inspection of the springs after installation, i.e. the spring must not be totally enclosed.
- 2.1.2 The springs shall have an outside diameter of not less than 75% of the operating height, and be selected to have at least 50% overload capacity before becoming coil-bound.
- 2.1.3 The bottom plate of each mounting shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs.
- 2.1.4 Mountings incorporating snubbers or restraining devices shall be designed so that the snubbing, damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine.
- 2.1.5 All nuts, bolts or other elements used for adjustment of a mounting shall incorporate locking mechanisms to prevent the isolator going out of adjustment as a result of vibration or accidental or unauthorised tampering.

2.2 Type B Mounting (Open Spring Type)

- 2.2.1 Each mounting shall consist of one or more helical steel springs as the principal isolation elements, and shall incorporate a built-in levelling device.
- 2.2.2 The springs shall be fixed or otherwise securely located to cast or fabricated top and bottom plates, shall have an outside diameter of not less than 75% of the operating height, and shall be selected to have at least 50% overload capacity before becoming coil-bound.
- 2.2.3 The bottom plate shall have bonded to it a rubber/ neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

2.3 Type C Mounting (Rubber/Neoprene Type)

Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant rubber/neoprene. Each mounting shall be capable of being fitted with a levelling device, and should have bolt holes in the base plate and a threaded metal insert in the top plate so that they can be bolted to the floor and equipment where required.

3.0 Plant Bases

3.1 Type A Bases (A.V. Rails)

An A.V. Rail shall comprise a steel beam with two or more height-saving brackets. The steel sections must be sufficiently rigid to prevent undue strain in the equipment and if necessary should be checked by the Structural Engineer.

3.2 Type B Bases (Steel Plant Bases)

Steel plant bases shall comprise an all-welded steel framework of sufficient rigidity to provide adequate support for the equipment, and fitted with isolator height saving brackets. The frame depth shall be approximately 1/10 of the longest dimension of the equipment with a minimum of 150 mm. This form of base may be used as a composite A.V. rail system.

3.3 Type C Bases (Concrete Inertia Base: for use with steel springs)

These shall consist of an all-welded steel pouring frame-work with height saving brackets, and a frame depth of approximately 1/12 of the longest dimension of the equipment, with a minimum of 100 mm. The bottom of the pouring frame should be blanked off, and concrete (2300 kg/m³) poured in over steel reinforcing rods positioned 35 mm above the bottom. The inertia base should be sufficiently large to provide support for all parts of the equipment, including any components which over-hang the equipment base, such as suction and discharge elbows on centrifugal pumps.