KP Acoustics Ltd.
info@kpacoustics.com
1 Galena Road, W6 0LT London, UK
+44 (0) 208 222 8778
www.kpacoustics.com

1-9 Sheldon House, Cromwell Road Teddington

Planning Compliance Report
Report 22965.NIA.01 RevA

Airey Miller

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Written by:	Checked by:	Approved by:
Jacob Tyler MIOA Acoustic Consultant	**Kyriakos Papanagiotou MIOA** Managing Director	**Kyriakos Papanagiotou MIOA** Managing Director

KP acoustics

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1.0 INTRODUCTION

KP Acoustics Ltd has been commissioned by Airey Miller, to assess the suitability of the site at 1-9 Sheldon House, Cromwell Road for a residential development in accordance with the provisions of the National Planning Policy Framework and the Noise Policy Statement for England (NPSE).

A 24 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 Richmond upon Thames.

This report presents the results of the environmental survey undertaken in order to measure prevailing background noise levels and outlines any necessary mitigation measures.

2.0 SITE SURVEYS

2.1 Site Description

As shown in Figure 2.1, the site is located within a residential area and bounded by Cromwell Road to the north, Fairfax Road to the east and a trainline to the south.

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 typical of an urban cityscape environment, with the dominant source being road traffic from the surrounding roads and train noise towards the rear of the site.

2.2 Environmental Noise Survey Procedure

Continuous automated monitoring was undertaken for the duration of the noise survey between 15:00 on 21 July 2021 and 16:00 on 22 July 2021.

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 Figures 2.2.

Icon	Descriptor	Location Description
	Noise Measurement Position 1	The meter was installed adjacent to the trainline at a height of approximately 1.5 metres above ground level.
	Noise Measurement Position 2	The meter was installed adjacent to the Sheldon House at a height of approximately 1.5 metres above ground level.

Table 2.1 Measurement position and description

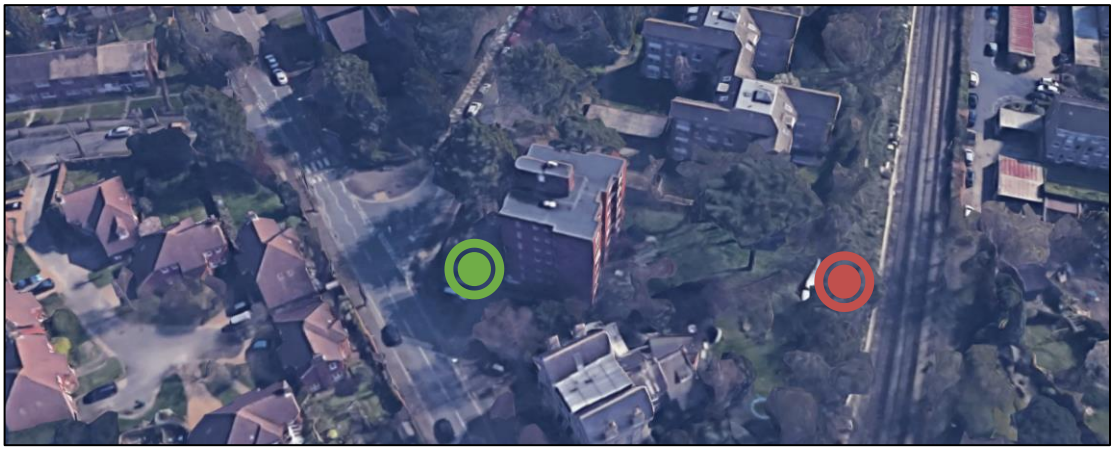

Figure 2.2 Site measurement position, identified receiver and proposed plant unit installation (Image Source: Google Maps)

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 2.3.

Measurement instrumentation		Serial no.	Date	Cert no.
Noise Kit 10	Svantek Type 971 Sound Level Meter	55541	03/09/2020	14012949-01
	Aco Pacific 7052E Free-field microphone	70821		

Measurement instrumentation		Serial no.	Date	Cert no.
	Preamp Svantek SV18	75770		
	Svantek External windshield	-	-	-
Noise Kit 12	Svantek Type 977C Sound Level Meter	97476	04/01/2021	Factory Calibrated
	Microtech type MK255	20070		
	Preamp Svantek SV12L	106915		
	Svantek Environmental Microphone Shroud	-	-	-
Larson Davis CAL200 Class 1 Calibrator		17148	27/04/2021	05223/1

Table 2.3 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 histories in Figures 22965.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 levels have been derived from the most commonly occurring (modal) $L_{A90,5\ min}$ levels measured during the environmental noise survey undertaken on site.

Time Period	Representative background noise level L_{A90} dB(A)	
	Noise Measurement Position 1	Noise Measurement Position 2
Daytime (07:00-23:00)	56	54
Night-time (23:00-07:00)	35	35

Table 3.1 Representative background noise levels

Measured noise levels are representative of noise exposure levels expected to be experienced by all facades of the proposed development, and are shown in Table 3.2.

Time Period	Noise Measurement Position 1 (Measured Noise level – dBA)	Noise Measurement Position 2 (Derived Noise level – dBA)
Daytime $L_{Aeq,16hour}$	64	61
Night-time $L_{Aeq,8hour}$	56	53

Table 3.2 Site average noise levels for daytime and night time

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 ($L_{Aeq,\ Tr}$), 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 criterion of London Borough of Richmond upon Thames for noise emissions of new plant in this instance is as follows:

"All industrial and commercial development with the potential to generate noise will be assessed and, where relevant, controlled by planning conditions in order to protect residential amenity. Conditions may be used, for example, to restrict noise levels and to control hours of operation. The most relevant standard for assessing new industrial and commercial development is BS4142:2014.

The Borough will not impose unreasonable restrictions on businesses but applicants should be aware that it is usually simpler and less expensive to design in noise management and noise control measures at the planning stage rather than wait for complaints to arise.

As a general rule, the Borough will seek to achieve the external noise standards detailed in the table below."

Noise Significance Risk	BS4142 Outcome	Planning Advice
Minimal	$L_{A,Tr} - L_{A90,T} \leq -5$	Where the rating level of noise is below the background noise level by at least 5dB, this indicates that the proposed NGD is likely to be acceptable from a noise perspective. The Borough will seek this level of compliance in most noise sensitive areas and/or where there is a requirement to mitigate creeping background effects.
Low	$L_{A,Tr} - L_{A90,T}$ is > -5 & ≤ 0	Where the rating level of noise is equal to, or below the background noise level by up to 5dB, this indicates that the proposed NGD may be acceptable from a noise perspective but will be more context dependent, i.e. extent and effect on noise sensitive receivers (externally and internally). Compliance within this range is more applicable to less sensitive sites or where there is no requirement to mitigate creeping background effects.
Medium	$L_{A,Tr} - L_{A90,T}$ is > 0 & $\leq +5$	Where the rating level of noise is equal to, or above the background noise level by up to 5dB, this indicates that the proposed NGD is less likely to be acceptable from a noise perspective and will be context dependent, i.e. extent and effect on noise sensitive receivers (externally and internally). Compliance within this range is typically only applicable to non-sensitive sites or where there are overriding other reasons why development should be considered. It will typically be necessary for the applicant to confirm how adverse impacts from the NGD will be mitigated and minimised. It is less likely that planning consent will be granted.
High	LA,Tr – LA90,T $> +5$	Where the rating level of noise is above the background noise level by more than 5dB, this indicates that the proposed NGD is unlikely to be acceptable from a noise perspective and planning consent is likely to be refused on noise grounds.

Table 4.1 New industrial and commercial development

4.3 Noise Policy Statement for England 2019

The National Planning Policy Framework (NPPF) has superseded and replaces Planning Policy Guidance Note 24 (PPG24), which previously covered issues relating to noise and planning in England. Paragraph 170 of the NPPF states that planning policies and decisions should aim to:

- preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans

In addition, Paragraph 180 of the NPPF states that '*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

The Noise Policy Statement for England (NPSE) was developed by DEFRA and published in March 2010 with the aim to 'Promote good health and good quality of life through the effective management of noise within the context of Government policy on sustainable development.'

Noise Policy Statement England (NPSE) noise policy 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*

The Noise Policy Statement England (NPSE) outlines observed effect levels relating to the above, as follows:

- NOEL – No Observed Effect Level

- This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

- LOAEL – Lowest Observed Adverse Effect Level
  - This is the level above which adverse effects on health and quality of life can be detected.

- SOAEL – Significant Observed Adverse Effect Level
  - This is the level above which significant adverse effects on health and quality of life occur.

As stated in The Noise Policy Statement England (NPSE), it is not currently possible to have a single objective based measure that defines SOAEL that is applicable to all sources of noise in all situations. Specific noise levels are not stated within the guidance for this reason, and allow flexibility in the policy until further guidance is available.

4.4 BS8233:2014

BS8233:2014 *'Sound insulation and noise reduction for buildings'* describes recommended internal noise levels for residential spaces. These levels are shown in Table 4.2.

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Rooms	35 dB(A)	-
Dining	Dining Room/area	40 dB(A)	-
Sleeping (daytime resting)	Bedrooms	35 dB(A)	30 dB(A)

Table 4.2 BS8233 recommended internal background noise levels

It should be noted that the recommended internal noise levels outlined above are not applicable under "purge ventilation" conditions as defined by Approved Document F of the Building Regulations, as this should only occur occasionally (E.G. to remove odour from painting or burnt food). However, the levels above should be achieved whilst providing sufficient background ventilation, either via passive or mechanical methods.

The external building fabric would need to be carefully designed to achieve these recommended internal levels.

4.5 Approved Document O (ed. 2021)

Approved Document O (ADO) supports Part O of Schedule 1 to the Building Regulations 2010. ADO introduces requirements for residential premises in order to prevent overheating from occurring. There are two specific requirements from ADO:

Requirement O1 (1):

To limit unwanted solar gains in summer and to provide adequate means to remove heat from the indoor environment.

Requirement O1 (2):

(a) Account must be taken of the safety of the occupant, and their reasonable enjoyment of the residence.

(b) Mechanical cooling may only be used where sufficient heat cannot be removed from the indoor environment without it.

The statutory guidance to support Requirement O1(2)(a) contains requirements relating to noise at night.

4.5.1 Application

The guidance within ADO applies to new residential buildings only and are defined within the following table:

Title	Purpose for which the building is intended to be used.
Residential (dwellings)	Dwellings, which includes both dwellinghouses and flats.
Residential (institutions)	Home, school or other similar establishment, where people sleep on the premises. The building may be living accommodation for the care or maintenance of any of the following. A. Older and disabled people, due to illness or other physical or mental condition. B. People under the age of 5 years.
Residential (other)	Residential college, hall of residence and other student accommodation, and living accommodation for children ages 5 years or older.

Table 4.2 Residential buildings within the scope of ADO (ref. Table 0.1 of Approved Document O)

Paragraphs 3.2 and 3.3 of ADO specifically refer to noise within bedrooms at night. Whilst any habitable room could be used as a bedroom, it is proposed that the scope is confined to those rooms specifically designated as bedrooms.

4.5.2 Internal Noise Level Targets

ADO sets internal noise level targets within Paragraph 3.3 of the document:

"Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.

a. 40dB $L_{Aeq,T}$, averaged over 8 hours (between 11pm and 7am)

b. 55dB L_{AFmax}, more than 10 times a night (between 11pm and 7am)."

Where an openable window for the removal of excess heat is predicted to result in the above internal noise levels to be exceeded, then the overheating mitigation strategy must adopt one of the alternative means listed within Paragraph 2.10 of ADO (presented within Section 4.7.3 of this report). This constraint applies regardless of which method is used to demonstrate compliance with Requirement O1 (1).

4.5.3 Methods to Remove Excess Heat

Paragraph 2.10 of ADO lists the means for removing excess heat from dwellings according to the following:

- Openable windows
- Ventilation louvres in external walls
- A mechanical ventilation system
- A mechanical cooling system

4.6 PLANT NOISE EMISSIONS CRITERIA

As the proposed plant could be used at any time of the day or night, the criteria have been set as shown in Table 4.5 in order to comply with the above requirements.

Description	External plant noise emissions criteria	
	Daytime (07:00-23:00)	Night-time (23:00-07:00)
Noise sensitive receptors to the north	49	30
Noise sensitive receptors to the south	51	30

Table 4.5 Proposed noise emissions criteria

5.0 PLANT NOISE IMPACT ASSESSMENT

We understand that the current building services strategy is yet to be confirmed.

In order for us to carry out an assessment of plant noise on the nearest noise sensitive receptor, we require the following:

If specific details are known (i.e. exact make, model and location of plant):

- Details of proposed items of plant, including type, quantity, make, manufacturer;
- manufacturer's test data presenting octave band sound power/sound pressure levels and details of the testing methodology;
- proposed locations of plant including any architectural/building services drawings.

If specific details are not known:

- Details of proposed items of plant, including type and quantity (for example 2No. condensers, 1No. extract fan);
- proposed locations of plant.

6.0 EXTERNAL BUILDING FABRIC SPECIFICATION

Sound reduction performance calculations have been undertaken in order to specify the minimum performance required from glazed and non-glazed elements in order to achieve the recommended internal noise levels shown in Table 4.2.

Please note that the glazed and non-glazed element calculations would need to be finalised once all design proposals are finalised.

6.1 Non-Glazed Elements

At this project stage, the exact construction of the non-glazed external building fabric is unknown, however, it is understood that it would be based upon the construction proposed in Table 6.1 and would be expected to provide the minimum figures shown above when tested in accordance with BS EN ISO, 140-3:1995.

Element	Octave band centre frequency SRI, dB					
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz
Blockwork Cavity Wall	41	43	48	50	55	55

Table 6.1 Assumed sound reduction performance for non-glazed elements

6.2 Glazed Elements

Minimum octave band sound reduction index (SRI) values required for all glazed elements to be installed are shown in Table 6.2.The performance is specified for the whole window unit, including the frame and other design features such as the inclusion of trickle vents. Sole glass performance data would not demonstrate compliance with this specification.

Glazing performance calculations have been based both on average measured night-time noise levels. The combined most robust results of these calculations are shown in Table 6.2.

Elevation	Octave band centre frequency SRI, dB						$R_w (C;C_{tr})$, dB
	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	
North Elevations	26	27	34	40	38	46	37 (-1; -4)
South Elevations	24	20	25	34	37	35	31 (-2;-4)

Table 6.2 Required glazing performance

The nominated glazing supplier should verify that their proposed window system meets the attenuation figures shown at each centre frequency band as shown in Table 6.2.

Example glazing types that would be expected achieve the above spectral values are shown in Table 6.3.

Elevation	Example glazing type
North Elevations	10/12/6mm
South Elevations	4/12/4mm

Table 6.3 Example glazing types

The elevations described above are presented within the following figure.

Figure 6.1 Example glazing elevations

All major building elements should be tested in accordance with BS EN ISO 140-3:1995.

Independent testing at a UKAS accredited laboratory will be required in order to confirm the performance of the chosen system for an actual configuration.

7.0 VENTILATION AND OVERHEATING

7.1 Ventilation Strategy

Based on the noise levels measured on site, appropriate ventilation systems are outlined in Table 7.1 below in order to ensure the internal noise environment is not compromised.

Ventilation System	Whole Dwelling Ventilation	Extract Ventilation
ADF System 1	Trickle vents providing a minimum performance of 35dB $D_{,n,e,w}$	Intermittent extract fans
ADF System 3	Continuous mechanical extract (low rate) and trickle vents for supply providing a minimum performance of 35dB $D_{,n,e,w}$	Continuous mechanical extract (high rate) with trickle vents providing inlet air
ADF System 4	Continuous mechanical supply and extract (low rate)	Continuous mechanical supply and extract (high rate)

Table 7.1 Ventilation systems

In the case of mechanical ventilation, systems should be designed to meet the internal noise levels as defined in CIBSE Guide A (2015), as shown in Table 7.2.

Room Type	LAeq, dB	NR
Bedrooms	30	25
Living Rooms	35	30
Kitchen	45-50	40-45

Table 7.2 CIBSE Guide A 2015 guidance levels for mechanical building services

7.2 Openable Windows

Approved Document O (ADO) only applies to Bedrooms during night. The advice within this section would therefore only apply to Bedrooms during night-time hours (23:00-07:00) to ensure that the internal noise level targets of 40dB(A) $L_{eq,T}$ and 55dB(A) L_{max} are not exceeded.

Table 7.3 presents the open area of the window as a % of the floor area which would need to be achieved to ensure that sufficient attenuation is provided from outside to inside.

Elevation	Sound Reduction Required to Achieve ADO Target Internal L_{Aeq} Noise Levels	Sound Reduction Required to Achieve ADO Target Internal L_{Amax} Noise Levels	Maximum Open Area of the Window as a Percentage of the Floor Area to Achieve ADO Target Internal Noise Levels
North	16 dB	25 dB	0 %
South	13 dB	21 dB	0 %

Table 7.3 Window open areas

The overheating model should inform the design team whether the % open areas above would be sufficient to remove excess heat. In the event they are insufficient, other options to limit solar gains into the building should be investigated (such as those outlined in Section 2.7 of Approved Document O), or other means of removing excess heat should be explored (as outlined in Section 2.10 of the Approved Document).

Note: Acoustic open area is the measurable, cross-sectional, geometric area of an opening. For a partially open window, this is considered to be the lesser of either the size of the hole in the window frame that is left by the opening light, or the combined cross-sectional area around the opening light through which air must pass to move from outside to inside. The area around a hinged opening light includes the triangular areas on the sides adjacent to the hinge, and the rectangular area on the side opposite the hinge. This should not be used for comparing the air-flow performance of elements because this will also be dependent on factors such as depth (length of air-path), surface roughness and tortuosity.

7.3 Overheating Control Strategies

Where the open areas specified above are not sufficient for controlling overheating, then one or more of the following strategies will need to be adhered to:

- Fixed shading devices comprising any of the following:
  - Shutters
  - External blinds
  - Overhangs
  - Awnings
- Glazing design, involving any of the following solutions
  - Size
  - Orientation
  - G-value
- Building design, e.g. the placement of balconies
- Shading provided by adjacent buildings structures or landscaping.
- Ventilation louvres in external walls

- A mechanical ventilation system
- A mechanical cooling system

8.0 CONCLUSION

An environmental noise survey has been undertaken at 1-9 Sheldon House, by KP Acoustics Ltd between 15:00 on 21 July 2021 and 16:00 on 22 July 2021. The results of the survey have enabled a representative background noise level to be set.

Plant noise emissions criteria have been set based upon the results of the environmental noise survey and the requirements of the Local Authority.

Upon receipt of the building services strategy, we will assess the plant noise emissions on the nearest noise sensitive receptor and provide mitigation advice if required.

Measured noise levels allowed a robust glazing specification to be proposed which would provide internal noise levels for all residential environments of the development commensurate to the design range of BS8233.

The mitigation measures described would be sufficient to protect the proposed residential properties from external noise intrusion, and to achieve internal noise conditions for the residents which would be commensurate to all current Standards.

The maximum openable area for bedroom windows within the development have been presented based upon the requirements of Approved Document O.

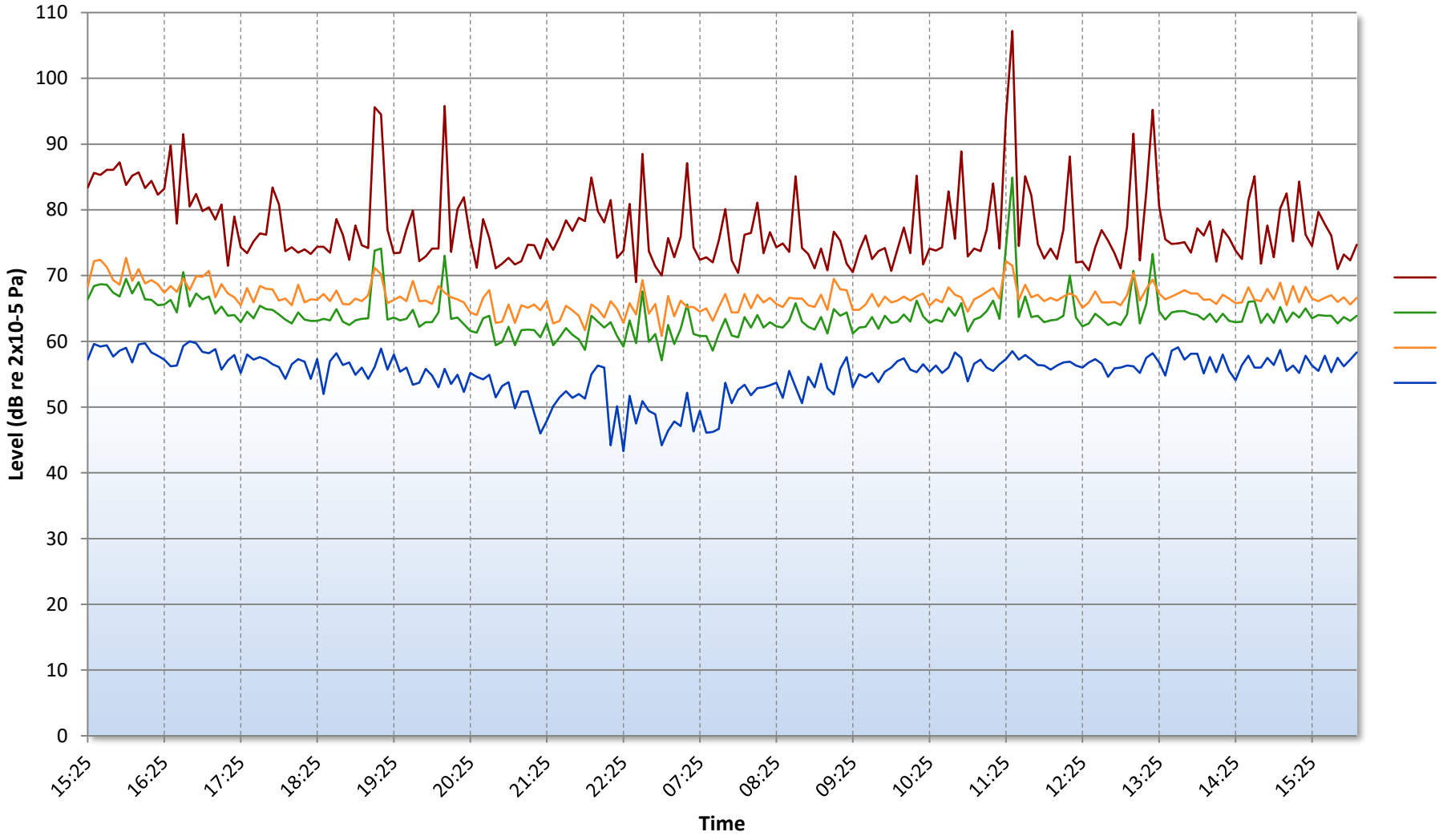
1-9 Sheldon House - Position 1
Environmental Noise Time History
From 22 July 2021 To 23 July 2021
Level (dB re 2x10-5 Pa)
110
100
90
80
70
60
50
40
30
20
10
0
15:25
16:25
17:25
18:25
19:25
20:25
21:25
22:25
07:25
08:25
09:25
10:25
11:25
12:25
13:25
14:25
15:25
Time

Figure 229

1-9 Sheldon House - Position 2
Environmental Noise Time History
From 22 July 2021 To 23 July 2021

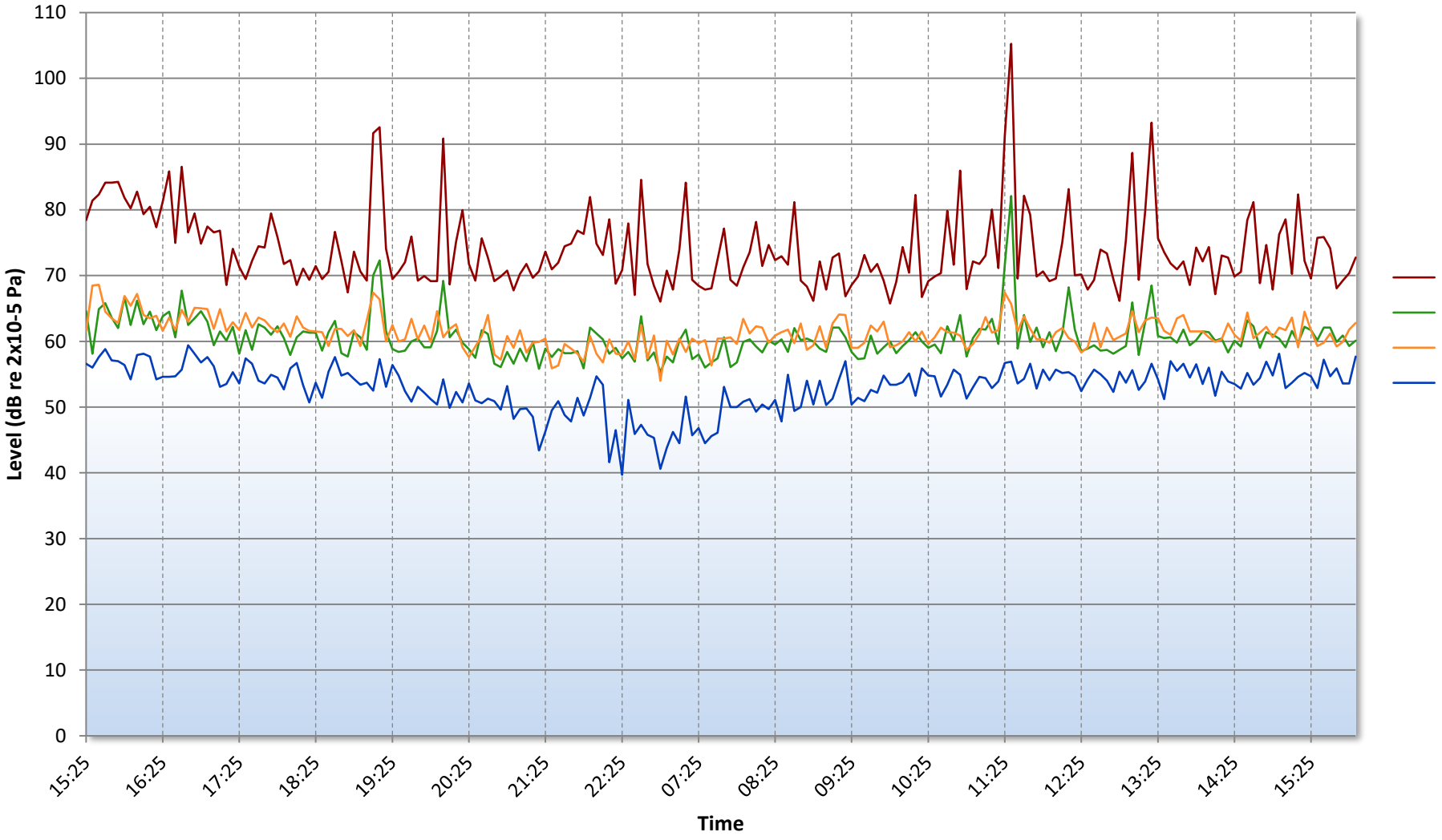

Figure 229(

APPENDIX A

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*.

APPENDIX A

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.