

British Museum IIP Works
Gallery 1 Condenser – Environmental Noise Assessment

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Glossary

Term	Definition
α (α_w)	Sound Absorption Coefficient (Weighted Sound Absorption Coefficient) is a measure of the effectiveness of materials as sound absorbers as defined in BS EN ISO 11654:1997. It is the ratio of the sound energy absorbed or transmitted (i.e. not reflected) by a surface to the total sound energy incident upon that surface. The value of the coefficient varies from 0 (perfect reflector) to 1 (perfect absorber).
A (A_T)	Absorption Area (Total Absorption Area) is equal to the product of multiplying the surface area of a construction (in m^2) and its Sound Absorption Coefficient (α).
Ambient Noise (as defined in BS 4142:2014+A1 2019)	Totally encompassing noise in a given situation at a given time; it is usually composed of noise from many sources, near and far.
Background Noise (as defined in BS 4142:2014+A1 2019)	A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90% of a given time interval, T, measured using the Fast time weighting and quoted to the nearest whole number of decibels.
C_{tr}	Spectrum adaptation term calculated using traffic noise as described in BS EN ISO 717-1:2013. This term is provided with weighted single values such as $D_{nT,w}$ or R_w to match with particular requirements (building acoustic or traffic noise spectrum).
Decibel, dB	Decibel (dB) is a dimensionless unit commonly used to demonstrate sound levels. It is derived from the logarithm of the ratio between the measured level and the reference value. For sound pressure level (L_p) the reference value is 2×10^{-5} pascals. For sound power (L_w) reference value is 1×10^{-12} Watts.
Flanking Noise	The transmission of sound around the perimeter or through holes within partitions (or barriers) that reduces the otherwise obtained sound transmission loss of a partition. Examples of flanking paths within buildings are ceiling plenum above partitions or raised floor cavities, ductwork, piping, and electrical conduit penetrations through partitions, back to back electrical boxes within partitions, window mullions, etc.
Frequency	Number of cycles per second, measured in hertz (Hz), related to sound pitch.
IANL	Indoor Ambient Noise Level. For schools Table 1 in BB93 (2015) specifies the upper limit for indoor ambient noise levels within teaching areas. The design criteria is set for a 30-minute average level (i.e. $L_{Aeq,30mins}$). However, where there is negligible change in the noise level, BB93 states that a much shorter time period (e.g. $L_{Aeq,5min}$) can be used. BB93 also states that for rooms identified having limits of $L_{eq,30min}$ 35 dBA or less, the noise should not regularly exceed $L_{1,30min}$ 55 dBA.
$L_{90,T}$ ($L_{A90,T}$)	Sound pressure level exceeded for 90% of the measurement period. Referred to as background noise level.
$L_{Ar,T}$	Rating Noise Level (as defined in BS 4142:2014+A12019), the specific noise level plus any adjustment for the characteristic features of the noise.
$L_{eq,T}$ ($L_{Aeq,T}$)	The equivalent continuous noise level of a time-varying noise. It is the steady noise level which, over the period of time under consideration, contains the same amount of sound energy as the time-varying noise over the same period of time.
$L_{Fmax,T}$ ($L_{AFmax,T}$)	The maximum sound pressure level measured during the measurement period T using the fast time constant.
$L_{n,w}$	Weighted Normalized Impact Sound Pressure Level: European single figure rating for transmission loss of impact sound through building elements as described in BS EN ISO 10140-3:2010+A1:2015 and BS EN ISO 717-2:2013. The lower the $L_{n,w}$ the better the performance.
L_p	Sound pressure level, in decibels, of a sound is 20 times the logarithm to the base of 10 of the ratio of the sound pressure to the reference pressure (2×10^{-5} pascals). The reference pressure shall be explicitly stated and is defined by standard.

Term	Definition
Noise Rating (NR)	Curves developed by the International Organization for Standardization (ISO) to determine the acceptable indoor environment for hearing preservation, speech communication and annoyance. These can be compared to NC curves and also can be approximated to equivalent dBA levels.
Reverberation Time (RT)	Time required for the steady sound pressure level in an enclosed space to decay by 60 dB, measured from the moment the sound source is switched off. Reverberation time is described in ISO 354:2003.
R_w (C , C_{tr})	Weighted Sound Reduction Index: Single-figure value of sound reduction according to BS EN ISO 10140-2:2010 used for rating partition systems, door-sets or glazing, based on the values of sound reduction index R at different frequencies. The higher the R_w the better the performance.
SEL (L_{Ae})	Single Event Level: The sound level over one second which would have the same energy content as the whole event.
Sound absorption classes	<p>Sound absorption performance characteristics are defined by a class. Below is a diagram of the different classes of absorption available, taken from BS EN ISO 11654:1997. The y-axis is the absorption coefficient of the material with one being total absorption and zero being no absorption. The x-axis is the frequency of the sound.</p> <p>The graph illustrates the absorption coefficient α for different sound absorption classes across a frequency range from 250 Hz to 4000 Hz. The y-axis represents the absorption coefficient α, ranging from 0 to 1.0. The x-axis represents the frequency in Hz, ranging from 250 to 4000. The classes are stacked from top to bottom: Class A (light blue), Class B (light green), Class C (yellow), Class D (orange), Class E (red), and Unclassified (white). Each class shows a peak absorption coefficient around 500 Hz, with Class A having the highest peak (around 0.9) and Class E having the lowest (around 0.3). The absorption coefficient generally decreases as frequency increases beyond 1000 Hz.</p>
Specific Noise Level (as defined in BS 4142:2014+A1 2019)	The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval.
T_{mf}	Mid Frequency Reverberation Time: Within BB93, the reverberation time criteria are set in terms of the averaged value of the 500 Hz, 1000 Hz and 2000 Hz frequency bands. The various levels for T_{mf} are specified within Table 6 of BB93 (2015) and are generally upper limits. Usually the specified mid-frequency reverberation times are for 'finished but unoccupied and unfurnished rooms'.
Vibration	Force which oscillates about some specified reference point. Vibration is commonly expressed in terms of frequency such as cycles per second (cps), Hertz (Hz), cycles per minute (cpm) or (rpm) and strokes per minute (spm). This is the number of oscillations which occurs in that time period. The amplitude is the magnitude or distance of travel of the force.
Weightings (as defined in BS EN 61672:2013):	<p>A-Weighting: Frequency weighting devised to attempt to take into account the fact that human response to sound is not equally sensitive to all frequencies; it consists of an electronic filter in a sound level meter, which attempts to build in this variability into the indicated noise level reading so that it will correlate, approximately, with human response.)</p> <p>C-Weighting: One of the frequency weightings corresponding to the 100-phon contour and the closest to the linear or un-weighted value.</p>

1 Executive Summary

This acoustics report has been prepared as an environmental noise impact assessment of replacement mechanical plant proposed to serve the British Museum 'Enlightenment Gallery'.

The report details a desktop noise model assessment of noise breakout from ThermoKey JKR2490.C5 W3EIEPA(EC)S remote condensers units (eight units) upon noise sensitive receivers (NSRs); identified as existing residential NSRs and British Museum library and offices spaces.

The assessment of potential noise impacts were conducted, principally, in accordance with criteria specified within:

- City of Camden, "Camden's Local Area Requirements for Planning Applications" 2018.
- British Standard (BS) 8233:2014 – Guidance on sound insulation and noise reduction for buildings.

Via 3D acoustic noise modelling on CadnaA acoustic software, the report demonstrates the suitability of the ThermoKey JKR2490.C5 W3EIEPA(EC)S remote condenser units with respect to the plant sound power level emissions.

At the existing residential NSRs, $L_{A,r,T}$ sound pressure levels of 33 dB(A) are predicted. This is suitable against the LOAEL criteria set by Camden's Local Area Requirements for Planning Applications, demonstrating a noise rating level 10 dB below the existing ($L_{A90,T}$) background noise climate can be attained at the NSRs.

49 dB(A) and 48 dB(A) $L_{A,r,T}$ noise levels were respectively calculated on the British Museum library and offices spaces. This level of noise impact is suitable for study and work requiring concentration in the library and office space against the BS 8233:2014 criteria thresholds.

2 Introduction

2.1 Overview

Buro Happold have been appointed by the British Museum to carry out a noise impact assessment to support a planning application for the installation of new condenser units (ThermoKey JKR2490.C5 W3EIEPA(EC)S). The proposed plant is to replace the existing condenser unit currently serving The Enlightenment Gallery.

The Enlightenment Gallery is a mechanically ventilated room containing no operable windows. The purpose of the condenser units will be to provide ventilation and thermal comfort for occupants utilising the Gallery, whilst also sustaining a suitable room temperature to maintain the collection of King George III - comprising of around 65,000 volumes of printed books. The Enlightenment Gallery is shown in Figure 2—1.

2.2 Site Description

The proposed plant will replace the existing remote air-cooled condenser units in the plant compound located to the East side of the Museum. The plant location is indicated on the annotated aerial image displayed in Figure 2—2.

The building opposite the existing plant compound (shown Figure 2—3) is currently under construction. The first level is proposed to contain a library space, whilst the second and third levels are office spaces with operable windows.

The plant noise assessment within this report considers the potential noise impact from the eight ThermoKey JKR2490.C5 W3EIEPA(EC)S remote condenser units on the proposed British Museum office spaces, as well as the existing Noise Sensitive Receivers (NSRs) shown in Figure 2—2.

2.3 Scope of Work

The assessment details the potential noise impact of the replacement mechanical plant upon existing NSRs and the British Museum. In summary, the report includes the following:

- Description of the site and plant items proposed
- Acoustic criteria, set by pertinent planning guidelines and Camden Local Plan and Planning Application Requirements
- Environmental acoustic survey results, outlining existing baseline conditions at the site and surrounding area
- Plant noise breakout assessment upon the British Museum and NSRs
- Discussion of mitigation requirements against plant noise level limits and thresholds (where required).



Figure 2—1 The Enlightenment Gallery (Source: British Museum <https://www.britishmuseum.org/about-us/british-museum-story/architecture>)

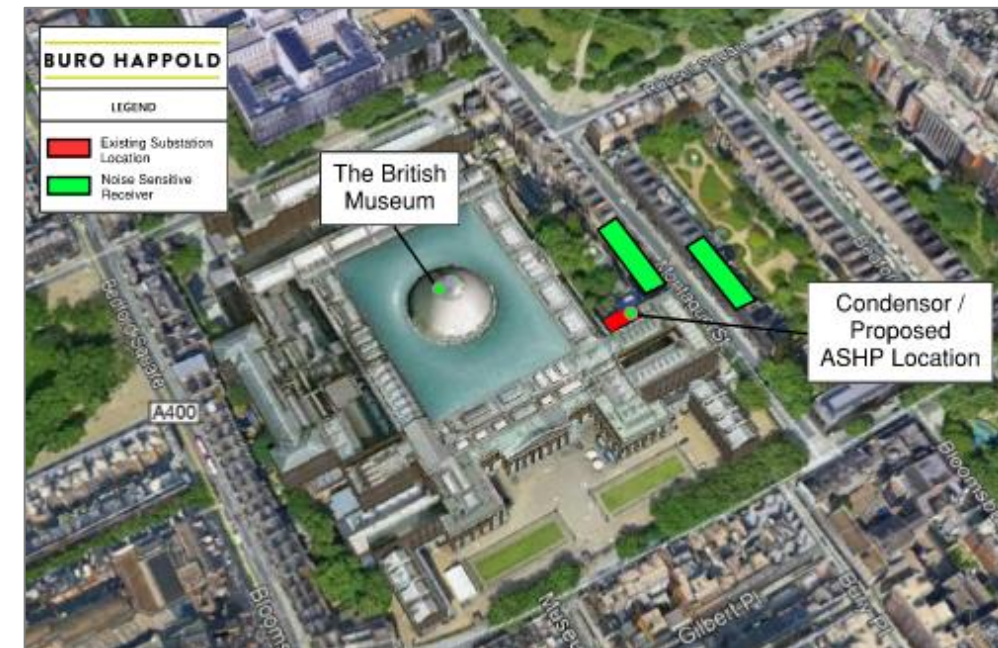


Figure 2—2 Annotated aerial site image illustrating plant location (Source: Google Earth @2020Google)



Figure 2—3 Existing Gallery 1 condenser within the plant compound

3 Acoustic Criteria

3.1 Noise Survey Guidance Documentation

Buro Happold were appointed by the British Museum to conduct an acoustic noise survey. This was undertaken in accordance with guidance and requirements within the following documents:

- BS 7445-1: 2003 “Description and measurement of environmental noise, Part 1: Guide to quantities and procedures, British Standards Institute”
- City of Camden, “Camden’s Local Area Requirements for Planning Applications” 2018.
- ISO 1996-1: 2016 “Acoustics - Description, measurement and assessment of environmental noise -- Part 1: Basic quantities and assessment procedures”
- ISO 1996-2: 2017 “Acoustics - Description, measurement and assessment of environmental noise -- Part 2: Determination of sound pressure levels”

3.1.1 Noise survey requirements

Shown in Figure 3—1, when change or replacement of plant is taking effect, Camden Local Authority requires that a 24-hour period noise survey is conducted, including the cumulative noise levels of all existing units.

3.2 Acoustic Design Criteria Documentation

The acoustic design criteria within this report is informed by the City of Camden *Local Plan, 2017*. The Camden Local Plan (2017), refers to the following standards and guidance documents:

- The National Planning Policy Framework, 2012 (NPPF)
- The Noise Policy Statement for England, 2010 (NPSE)
- British Standard (BS) 4142:2014 – Methods for rating and assessing commercial and industrial sound. The latest standard not referenced in the Development Sound Standard, BS4142:2014+A1:2019, supersedes the 2014 version and is adopted throughout this report.

The *Camden Local Plan, 2017* Policy A4 (shown in Figure 3—2) provides a summary of the Noise and Vibration aims for the Local Planning Authority.

In considering the noise impact from the JKR2490.C5 W3EIEPA(EC)S remote condenser units on the nearby British Museum office spaces, the following standard provides noise levels guidance:

- British Standard (BS) 8233:2014 – Guidance on sound insulation and noise reduction for buildings.

When is a noise, vibration and ventilation assessment needed?

You should send this with applications for developments including installing, changing or replacing plant, ventilation, extraction or air conditioning equipment.

What information should be included in a noise, vibration and ventilation assessment?

A noise, vibration and ventilation assessment should include the following information:

- existing background noise levels measured over a 24-hour period. This includes the cumulative noise levels of all existing units.
- proposed background noise levels. This includes the cumulative noise levels of all existing units.
- any proposed measures to reduce noise, fume emissions and vibration
- the system manufacturers specification of the proposed equipment to be installed, altered or replaced
- details of the method used to compile the report and examples of the calculations and assumptions made

Figure 3—1 City of Camden Noise Assessment Requirements. (Source: <https://www.camden.gov.uk/noise-vibration-ventilation-assessments>)

Policy A4 Noise and vibration

The Council will seek to ensure that noise and vibration is controlled and managed.

Development should have regard to Camden’s Noise and Vibration Thresholds (Appendix 3). We will not grant planning permission for:

- development likely to generate unacceptable noise and vibration impacts; or
- development sensitive to noise in locations which experience high levels of noise, unless appropriate attenuation measures can be provided and will not harm the continued operation of existing uses.

We will only grant permission for noise generating development, including any plant and machinery, if it can be operated without causing harm to amenity.

We will also seek to minimise the impact on local amenity from deliveries and from the demolition and construction phases of development.

Figure 3—2 Camden Local Plan, 2017 Noise and Vibration Policy excerpt (Source: <https://www.camden.gov.uk/documents/20142/4820180/Local+Plan.pdf/ce6e992a-91f9-3a60-720c-70290fab78a6>)

3.2.1 English planning policies on noise impacts

The National Planning Policy Framework (NPPF) is the overarching planning policy document for developments in England. The document contributes to sustainable development, aiming to protect or enhance the natural, built and historic environment, including the minimisation of pollution and waste. It is referenced in Appendix 3: Noise thresholds, within the *Camden Local Plan* to help determine the significance of noise impacts.

The NPPF document refers to the Noise Policy Statement for England (NPSE) specifically for noise impact. The NPSE provides guidance, which enables decisions to be made regarding the acceptable noise burden to place on society, using the three key phrases: No Observed Effect Level (NOEL), the Lowest Observed Adverse Effect Level (LOAEL) and the Significant Observed Adverse Effect Level (SOAEL). Shown in Figure 3—3, Camden council summarise this guidance into 3 basic design criteria of Green, Amber and Red colour coding.

3.2.2 Limiting plant noise levels

For the installation of industrial or commercial plant, the *Camden Local Plan* states that for both daytime and night-time periods, the plant rating level ($L_{Ar,Tr}$ dB(A)) should ideally be limited to 10 dB below the existing background noise level ($L_{A90,T}$ dB(A)) to achieve LOAEL impact. A further requirement at night is for no plant to exceed a 57 dB(A) L_{Amax} noise level (see Figure 3—4).

The rating limit and background noise level should be defined using the guidance contained in BS 4142:2014+A1:2019. BS 4142:2014 guidance is used to assess the noise impact of industrial and commercial sources on residential receptors and provides guidance as to the likely community response.

The impact is assessed by comparing the measured background sound level ($L_{A90,T}$ dB(A)), at a location representative of the nearest noise-sensitive receptor, to the 'rating level' ($L_{Ar,Tr}$ dB(A)) (the specific sound source to be introduced into the locality, corrected for acoustically distinguishing characteristics which may make it more subjectively prominent).

Based on the above and Figure 3—4, the target for new British Museum plant items are to achieve a green noise impact rating (LOAEL design criteria). Therefore, the design criteria are:

- To achieve a noise rating level (noise level including any BS 4142 characteristic penalties) that is as a minimum 10 dB below the background noise level at the curtilage of NSR
- Noise from plant items must not exceed 57 dB(A) L_{Amax} during night-time periods (23:00 – 07:00).

3.2.3 Emergency equipment operation

Additionally, the emergency equipment such as generators which are only to be used for short periods of time will be required to meet the more permissive noise criteria of no more than 10 dB above the background level ($L_{A90,15}$ minutes), allowable due to the intermittent operation. During standby periods, emergency equipment will be required to meet the usual criteria for plant and machinery. Conditions to this effect may be imposed in instances where emergency equipment forms part of the application.

3.2.4 British Standard 8233

BS 8233:2014 provides guidance for internal ambient noise levels (IANL) in non-domestic buildings. The design ranges relevant to the British Museum and this report are shown in Table 3—1. The IANL are typically a product of noise break-in through weaker elements of the façade (e.g. glazing) and any openings for ventilation.

Under open window ventilation conditions, the performance of the glass is immaterial, as any sound will simply travel through the opening. It is generally accepted that for a facade in which the window is open, the internal noise level would be 15 dB lower than the simultaneously occurring level outside of the window. To attain the lower level BS 8233:2014 internal ambient noise levels (40 for libraries and 35 dB(A) for offices), plant should therefore be designed to achieve $\leq L_{Aeq,T}$ 55 dB(A) @1m from the library façade and 50 dB(A) 1m from the office façade.

- NOEL – No Observed Effect Level
- LOAEL – Lowest Observed Adverse Effect Level
- SOAEL – Significant Observed Adverse Effect Level

Three basic design criteria have been set for proposed developments, these being aimed at guiding applicants as to the degree of detailed consideration needed to be given to noise in any planning application. The design criteria outlined below are defined in the corresponding noise tables. The values will vary depending on the context, type of noise and sensitivity of the receptor:

- Green – where noise is considered to be at an acceptable level.
- Amber – where 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 – where noise is observed to have a significant adverse effect.

Figure 3—3 Camden Local Plan, 2017 noise 'effect levels' design criteria (Source: <https://www.camden.gov.uk/documents/20142/4820180/Local+Plan.pdf/ce6e992a-91f9-3a60-720c-70290fab78a6>)

Table C: Noise levels applicable to proposed industrial and commercial developments (including plant and machinery)

Existing Noise sensitive receptor	Assessment Location	Design Period	LOAEL (Green)	LOAEL to SOAEL (Amber)	SOAL (Red)
Dwellings**	Garden used for main amenity (free field) and Outside living or dining or bedroom window (façade)	Day	'Rating level' 10dB* below background	'Rating level' between 0dB below and 5dB above background	'Rating level' greater than 5dB above background
Dwellings**	Outside bedroom window (façade)	Night	'Rating level' 10dB* below background and no events exceeding 57dB L_{Amax}	'Rating level' between 0dB below and 5dB above background or noise events between 57dB and 88dB L_{Amax}	'Rating level' greater than 5dB above background and/or events exceeding 88dB L_{Amax}

*10dB should be increased to 15dB if the noise contains audible tonal elements. (day and night). However, if it can be demonstrated that there is no significant difference in the character of the residual background noise and the specific noise from the proposed development then this reduction may not be required. In addition, a frequency analysis (to include, the use of Noise Rating (NR) curves or other criteria curves) for the assessment of tonal or low frequency noise may be required.

**levels given are for dwellings, however, levels are use specific and different levels will apply dependent on the use of the premises.

The periods in Table C correspond to 0700 hours to 2300 hours for the day and 2300 hours to 0700 hours for the night. The Council will take into account the likely times of occupation for types of development and will be amended according to the times of operation of the establishment under consideration.

Figure 3—4 Excerpt from the Camden Local Plan, 2017. Indicating the noise level thresholds for this report (Source: <https://www.camden.gov.uk/documents/20142/4820180/Local+Plan.pdf/ce6e992a-91f9-3a60-720c-70290fab78a6>)

Table 3—1 Typical noise levels in non-domestic buildings (Source: Table 6 in BS 8233:2014)

Activity	Location	Design Range dB(A) ($L_{Aeq,T}$)
Study and work requiring concentration	Library, Gallery, Museum	40-50
	Staff Meeting Room, Executive Office	35-40

4 Environmental Noise Survey

4.1 Introduction

Buro Happold staff visited the British Museum site to undertake short-term attended and long-term unattended noise measurements on Tuesday 15 September 2020 until Wednesday 16 September 2020.

The aim of the short-term measurements was to understand the noise levels produced by existing plant in and around the compound. The aim of the long-term measurement was to capture the existing background noise levels at noise sensitive receivers (i.e. residential dwellings). These allow the specification of limiting noise levels for the externally located JKR2490.C5 W3EIEPA(EC)S remote condenser units, to see that the installation will not unduly increase noise levels in the vicinity of the site, in line with relevant criteria.

4.2 Noise Measurement Locations

The Gallery 1 noise measurement locations are detailed below and marked on the annotated aerial image in Figure 4—1:

- ST1 – Short-term (multiple 5 minute) noise measurements conducted inside the plant compound. The aim of the measurement was to identify noise levels produced by the existing condenser unit
- ST2 – Short-term (multiple 5 minute) noise measurement conducted at ground level outside the plant compound. The aim of the measurement was to identify the noise levels produced by existing plant units located in this location
- ST3 – Short Term (multiple 5 minute) noise measurements conducted in the British Museum level 3 offices spaces - with the operable window fully opened.
- LT1 – Long-term (24 hour) noise measurement positioned by existing NSRs to capture the baseline noise climate during night-time periods.

4.2.1 Instrumentation

The following instrumentation was used during the noise survey, generally in accordance with BS EN 61672-1:2013, BS EN 61672-2:2013+A1:2017, and BS 7445:2003.

Table 4—1 Noise survey instrumentation

Instrumentation	Model No.	Serial Number
Sound Level Meter	RION NL-52	01265411
Acoustic Calibrator	CEL-284/2	3/01818662

The calibration of the meter was verified with a field calibration check before and after use, with no significant drift in level witnessed. Copies of the relevant laboratory calibration certificates associated with the meter are available upon request.

4.2.2 Weather conditions

The weather conditions during the survey were noted to have been between 10°C and 19°C in temperature. Wind speeds were no greater than 5 ms⁻¹.

Through the use of appropriate windshields and selection of monitoring positions, precautions were taken against weather and environmental factors affecting measurements and it is not considered that rain, wind or environmental electrical interference (e.g. overhead power lines) influenced readings.



Figure 4—1 Annotated aerial image indicating noise survey measurement locations ST1, ST2 and LT1 (Source: Google Earth, @2020Google).



Figure 4—2 Annotated aerial image indicating noise survey measurement location ST3 (Source: Google Earth, @2020Google).

4.3 Noise Survey Results

A summary of the results is detailed in the tables below. The included descriptors are as follows:

- $L_{Aeq,T}$ – the average A-weighted sound pressure level within a measurement period (typically 5, or 15 minutes in this case). Typically thought of as the average ambient noise level at a particular time and likely to be due to a combination of various noise sources, near and far
- $L_{A90,T}$ – the A-weighted sound pressure level exceeded for 90% of the measurement period. i.e. a level which would be perceived as a constant, background noise level. Typically, this measurement parameter is largely unaffected by local traffic pass-bys or transient events. It is more usually attributable to constantly running building services plant or distant road traffic (e.g. what you would hear when there is no local traffic pass-bys present (or other readily identifiable noise sources).

The “design level” values in the tables below are derived from the on-site measurements. These are calculated as follows:

- Existing Ambient $L_{Aeq,15min}$ – the logarithmic average of the measured $L_{Aeq,T}$ values, measured during the daytime (07:00 – 23:00) and night-time (23:00 – 07:00) periods.
- Background $L_{A90,15min}$ – the modal $L_{A90,15min}$ values captured during the survey period.

4.4 Noise Survey Discussion

On-site attended noise measurements at ST1 and ST2 (Figure 4—1), provide an indication of the noise emissions from existing plant located in the proposed vicinity of the JKR2490.C5 W3EIEPA(EC)S remote condenser units .

Inside the plant compound at ST1, Table 4—2 shows noise levels up to 61 dB(A) $L_{Aeq,T}$ were recorded at a 1 metre distance from the existing condenser unit.

Table 4—3 shows the noise levels at 1m from the subjectively loudest ground level plant (ST2 Figure 4—1). The chiller and condenser plant units at this location produce greater noise emissions compared to the condenser units within the plant compound, with $L_{Aeq,T}$ levels up to 71 dB(A) @1m.

As well as being subjectively louder and audible within the compound, the ground level plant units were noted on-site to run with intermittent boost periods. The higher power operation subsequently produced greater noise levels. Table 4—3 and measurements at the office window (ST3) in Table 4—4 were collected during the period of high-power chiller operation.

Table 4—5 details the results from the unattended long-term measurement (location LT1 in Figure 4—1). The lowest background noise levels were recorded during the night-time measurement periods (23:00-07:00). Appendix A contains the modal distributions of the $L_{A90,15min}$ noise levels. During both night-time measurements periods there are two distinct modal peaks on the histograms at 45/46 dB(A) and 53/54 dB(A) $L_{A90,15min}$. It is expected that the peaks occur due to low and high power operation periods of the ground level plant units (measured at ST2, Figure 4—1).

To reduce the potential noise impact of installing the new condenser units within the compound, the lower of the modal $L_{A90,15min}$ noise levels has been adopted as the design level (45 dB(A) $L_{A90,15min}$).

Table 4—2 Noise survey results and highlighted design levels at short-term measurement location 1

Measurement Date	$L_{Aeq,5minutes}$ (dBA)	$L_{A90,5minutes}$ (dBA)	$L_{AF,max}$ (dBA)	Notes
15/09/2020	61	58	73	Subjectively, the noise levels present were largely due to the existing plant within the compound. However, ground level chiller plant was noticeable at this location. Some construction noise from British Museum renovations was audible; however, this was not considered to unduly affect the noise levels recorded. No traffic noise was audible at this position.
	58	55	66	

Table 4—3 Noise survey results and highlighted design levels at short-term measurement location 2

Measurement Date	$L_{Aeq,5minutes}$ (dBA)	$L_{A90,5minutes}$ (dBA)	$L_{AF,max}$ (dBA)	Notes
15/09/2020	71	69	77	Noise levels dictated by the existing chiller plant approximately 1m from the sound level metre position. Existing Condenser was not audible in this location due to the ground level chiller plant. No traffic noise was audible at this position.

Table 4—4 Noise survey results and highlighted design levels at short-term measurement location 3

Measurement Date	$L_{Aeq,5minutes}$ (dBA)	$L_{A90,5minutes}$ (dBA)	$L_{AF,max}$ (dBA)	Notes
15/09/2020	53	46	68	Subjectively, the noise levels present were largely due to the existing plant within the compound. However, ground level chiller plant was noticeable at this location. Some construction noise from British Museum renovations was audible; however, this was not considered to unduly affect the noise levels recorded.
	51	47	62	

Table 4—5 Noise survey results and highlighted design levels at long-term measurement location 1

Measurement Date	Time Period	$L_{Aeq,15minutes}$ (dBA)	$L_{A90,15minutes}$ (dBA)	Notes
15/09/2020	15:15-22:59	50	55	Daytime Noise Measurement
15-16/09/2020	23:00-06:59	56	45*	Night-time Noise Measurement
16/09/2020	07:00-22:59	58	55	Daytime Noise Measurement
16-17/09/2020	23:00-06:59	54	46*	Night-time Noise Measurement
17/09/2020	07:00-13:15	60	55	Daytime Noise Measurement

*Noise climate consists of fluctuating $L_{A90,15min}$ levels. The lowest of the modal peaks (quieter noise level) during night-time measurement periods has been input into the table. Aiming to minimise the NPPF observed effect levels

5 Plant Noise Impact Assessment

5.1 Introduction

The JKR2490.C5 W3EIEPA(EC)S remote condenser units proposed to replace existing plant within the compound shown in Figure 2—3, should be limited according to policy detailed within the *Camden Local Plan, 2017* (detailed in Section 3 Acoustic Criteria).

New British Museum plant items must achieve a rating level difference (noise level including any penalties for acoustically distinguishing characteristic, as defined in BS 4142) of -10 dB compared to the background noise level at the curtilage of NSRs. Additionally, noise from plant items must not exceed 57 dB(A) L_{Amax} during night-time periods (23:00 – 07:00), assessed at the same location.

5.1.1 Limiting plant noise levels

In-situ background ($L_{A90,T}$) noise level measurements and subsequent plant noise limits at noise sensitive receivers are shown in Table 5—1. The condensers are understood to potentially run during the day and during the night. The more stringent value (i.e. the night-time value of $L_{A90,15min}$ 45 dB) will be used in assessment. It is noted that this requires plant to be limited to $L_{A,Tr}$ 35 dB.

Condensing plant typically runs at a constant level, with low impulsiveness. It is therefore considered unlikely that it is possible that the maximum permissible level of 57 dB(A) L_{Amax} during night-time periods (23:00 – 07:00) will be exceeded if the maximum permissible $L_{A,Tr}$ values are adhered to.

5.2 JKR2490.C5 W3EIEPA(EC)S Remote Condenser Unit Plant Proposal

It is understood that JKR2490.C5 W3EIEPA(EC)S remote condenser units have been proposed for installation, in place of the existing condenser units in the compound. The proposed units are proposed to be grouped together, essentially acting as a single noise source.

Manufacturer's data shows the eight condenser plant units are likely produce a cumulative broadband sound power level of L_w 69 dB(A). The octave band sound power levels used in the noise impact assessment have been reproduced in Table 5—2.

Table 5—1 Measured background noise levels and limiting plant noise levels at noise sensitive receivers

Typical measured daytime background noise $L_{A90,15min}$ dB(A) (07:00-23:00)	Plant daytime rating limit $L_{A,Tr}$ dB(A) (07:00-23:00)	Typical measured night-time background noise $L_{A90,15min}$ dB(A) (23:00-07:00)	Plant night-time rating limit $L_{A,Tr}$ dB(A) (23:00-07:00)
	LOAEL		LOAEL
55	45	45	35

LOAEL: green noise impact rating as defined by Camden Local Plan, 2017 (See Figure 3—4).

Table 5—2 JKR2490.C5 W3EIEPA(EC)S remote condenser unit sound power data (Source: ThermoKey Heat exchange Solutions, JKR2490.C5 W3EIEPA(EC)S Technical Data)

Plant Unit	Sound Power Level (dB) at octave band centre frequencies (Hz)							Broadband Sound Power (dB(A))
	63	125	250	500	1K	2k	4k	
JKR2490.C5 W3EIEPA(EC)S Single condenser unit	39	41	46	50	50	47	46	55
JKR2490.C5 W3EIEPA(EC)S Eight condenser units	50	54	59	62	63	63	61	69

5.3 Desktop Noise Model Impact Assessment

A noise modelling exercise has been undertaken using CadnaA 2019 acoustic modelling software to identify what the likely noise levels are at the façades of the NSRs and the British Museum, if the JKR2490.C5 W3EIEPA(EC)S remote condenser units were installed without additional noise mitigation elements (within the current enclosure). Figure 5—1, Figure 5—2 and Figure 5—3 on the following page show the highest calculated levels incident on the façades of the British Museum and on the nearest Noise Sensitive Receivers (NSRs).

5.4 Rating level

As discussed in Section 2.2.4, it is a requirement of BS 4142 that the subjective prominence of the specific sound is considered when assessing the likely impact at nearby noise sensitive receivers, based on the likelihood of any acoustically distinguishing characteristics of the specific sound which may attract attention (whilst considering the existing residual sound climate).

Buro Happold have considerable experience of mechanical plant. All Buro Happold staff are (minimum) degree-qualified engineering consultants in acoustics or a related discipline. Acoustics staff members involved in this scheme are corporate members of the Institute of Acoustics and therefore considered suitably qualified to make the following assessments.

5.4.1 Tonality

Noise associated with condenser units is not typically tonal in nature, given that the sound generation is typically associated with air movement and therefore includes sound associated with the motor, air displacement and turbulence. No corrections for tonality are therefore considered to be required.

5.4.2 Impulsivity

The condensers are not considered to have particularly steep 'ramp up' levels, nor do either have any features which rapidly interrupt the sound generation. On this basis, no corrections for impulsivity are considered to be required.

5.4.3 Intermittency

The condenser units will, on occasion, ramp down and then back up, in response to load demands. On this basis, a correction of +3 dB will be applied for intermittency.

5.4.4 Summary table – rating level

Table 5—3 shows the specific sound level, corrected for the various features given above to obtain the rating level required in BS 4142:2014+A1:2019. As can be seen, the cumulative corrections require that +3dB is added to the specific sound to generate a rating level at each receiver, which will be compared against the background sound level in the following assessment.

5.5 Noise Impact Discussion

Table 5—4 summarises the potential noise impact on both the British Museum and the NSRs compared to Camden Local Plan thresholds. The results below show the noise impact of the JKR2490.C5 W3EIEPA(EC)S remote condenser units when installed into the existing plant compound.

The results are based on the cumulative octave band sound power levels given in Table 5—2, and consider distance attenuation, air absorption and the effect of any screening, shielding or barriers (e.g. from the existing solid plant screen around the compound, which is to be retained). The results show predicted incident sound pressure levels on reception points, which have then been corrected in line with Table 5—3, to provide rating levels at each receiver. The modelling screenshots given below have been calibrated to show the impact of the rating level at various points around the development.

Table 5—3 Plant Rating Level

Value	Correction dB
Baseline specific sound level	-
Tonality correction	+ 0
Impulsivity correction	+ 0
Intermittency correction	+ 3
Rating correction	+3

Table 5—4 Measured background noise levels, limiting plant noise levels and predicted rating levels

Noise Sensitive Receiver	BS 8233: 2014 internal ambient noise level L _{Aeq,T} dB(A)	Plant rating limits at 1m from the façade L _{Ar,Tr} dB(A)	Highest calculated specific levels 1m from building facade L _{Aeq,T} dB(A)	Highest calculated rating levels 1m from building facade L _{Ar,Tr} dB(A)
Nearby residential dwellings	-	35	30	33
British Museum library	40	55	46	49
British Museum office	35 – 40	50 – 60	45	48

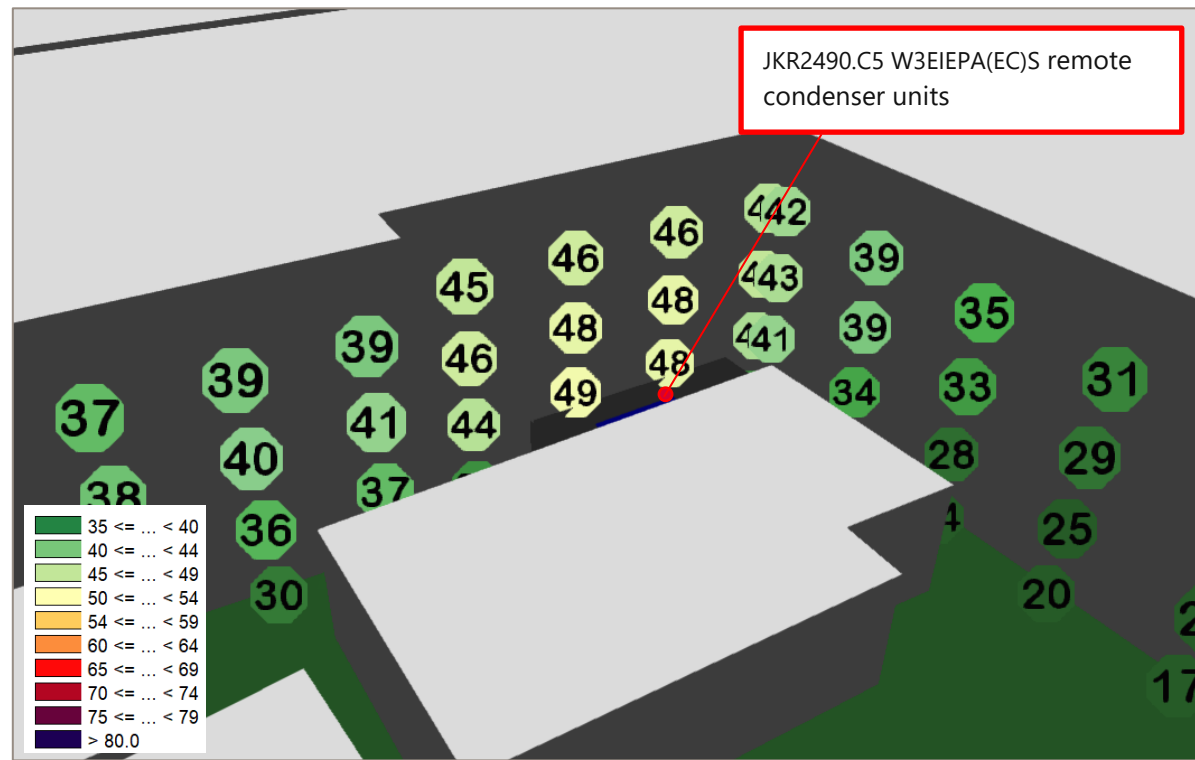


Figure 5—1 3D Acoustic CadnaA model, showing the calculated $L_{A,T,facade}$ noise levels on the British Museum due to noise emissions from the JKR2490.C5 W3EIEPA(EC)S remote condenser units



Figure 5—3 Highest calculated $L_{A,T,facade}$ noise levels due to noise emissions from the JKR2490.C5 W3EIEPA(EC)S remote condenser units

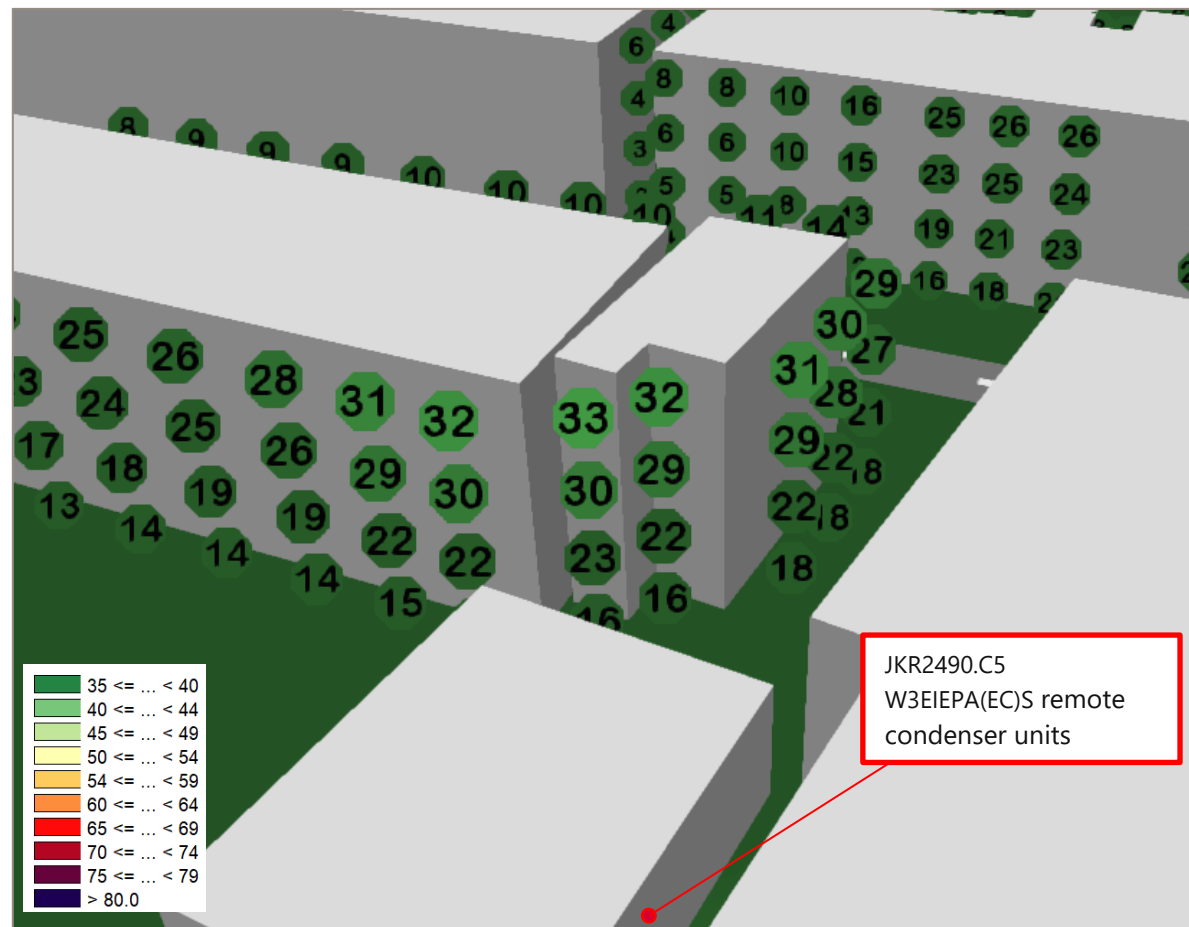


Figure 5—2 3D Acoustic CadnaA model, showing the calculated $L_{A,T,facade}$ noise levels on the NSR facades due to noise emissions from the JKR2490.C5 W3EIEPA(EC)S remote condenser units

5.6 Discussion

As can be seen from the tables and modelling screenshots given above, the predicted rating noise levels at all reception point (both noise-sensitive facades of the British Museum itself, and nearby noise-sensitive residential receptors) are below the maximum permissible limits set in Section 2.

Based on the calculated noise levels the JKR2490.C5 W3EIEPA(EC)S remote condenser units are therefore considered to be a suitable plant unit replacement against Camden's Local Area Requirements for Planning Applications (2018) and British Standard (BS) 8233:2014 internal ambient noise level criteria.

6 Conclusions

The noise impact of installing of the JKR2490.C5 W3EIEPA(EC)S remote condenser units were assessed against the following design criteria:

"Camden's Local Area Requirements for Planning Applications" 2018

Based on Local Planning Authority requirements new British Museum plant items must achieve a rating level difference (noise level including any penalties for acoustically distinguishing characteristic, as defined in BS 4142) of 10 dB compared to the background noise level at the curtilage of NSRs and must not exceed 57 dB(A) L_{Amax} during night-time periods (23:00 – 07:00).

British Standard (BS) 8233:2014

To attain the BS 8233:2014 internal ambient noise levels, designing the plant to achieve 55-60 dBA 1m from the library façade and 50 dBA 1m from the office façade.

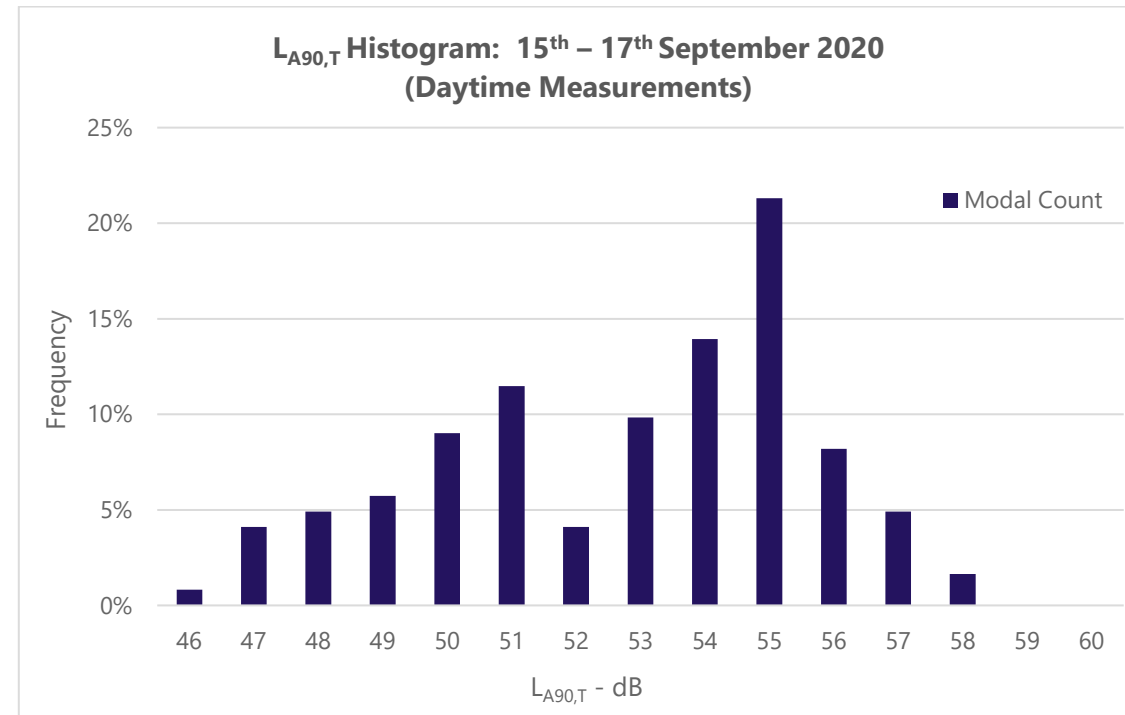
Assessment Outcomes

The report has demonstrated the suitability of the proposed plant selection (JKR2490.C5 W3EIEPA(EC)S remote condenser units) in terms of noise. The desktop noise model calculations predicted compliant noise levels at sensitive receivers as summarised in the table below:

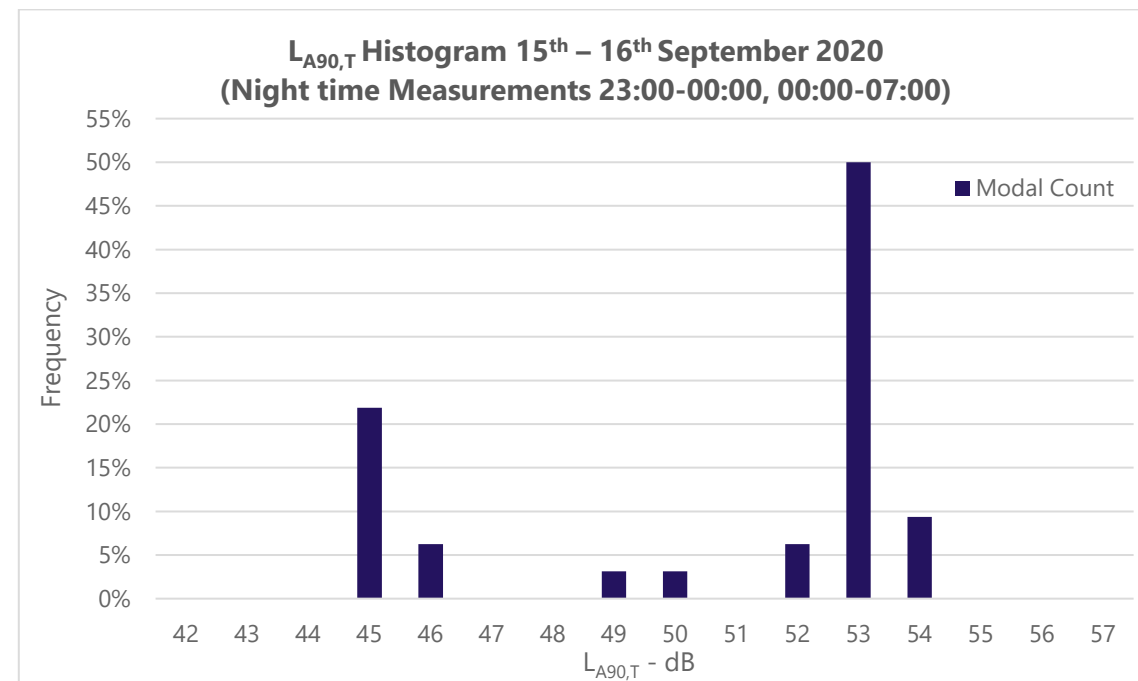
Noise Sensitive Receiver	Plant rating limits at 1m from the façade $L_{Ar,T}$ dB(A)	Highest calculated levels 1m from building facade - dB(A)	Compliant / Not Compliant
Nearby residential dwellings	35	33	Compliant
British Museum library	55	49	Compliant
British Museum office	50 – 60	48	Compliant

Appendix A Modal Background Noise Level (L_{AF90,T}) Measurements

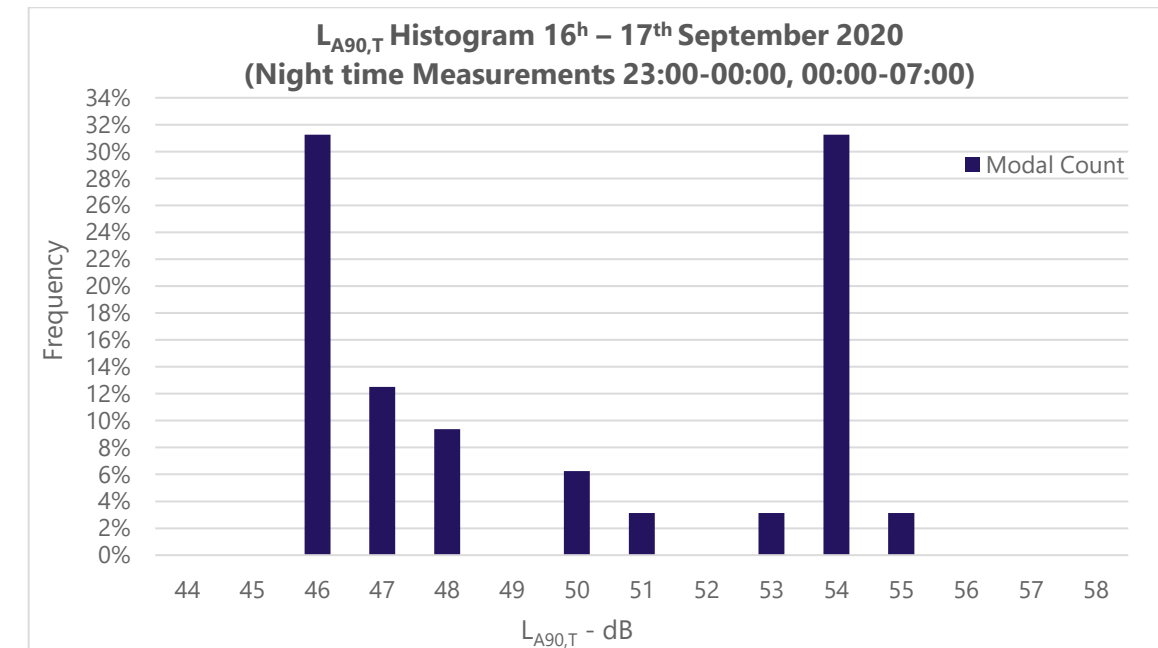
A.1 15th – 17th September 2020 (Daytime Measurements)



A.2 15th – 16th September 2020 (Night-time Measurements 23:00-00:00, 00:00-07:00)



A.3 16^h – 17th September 2020 (Night-time Measurements 23:00-00:00, 00:00-07:00)



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