BURO HAPPOLD

British Museum IIIP Works
The Pizzeria Extract Fan - Environmental Noise Assessment

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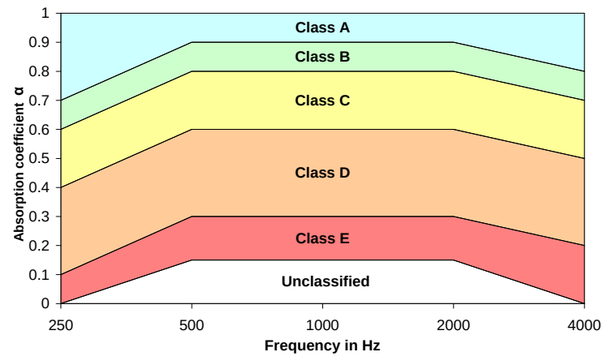
Glossary

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 $2x10^{-5}$ pascals. For sound power (L_w) reference value is $1x10^{-12}$ 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 ($2x10^{-5}$ 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	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. 
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):	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.). C-Weighting: One of the frequency weightings corresponding to the 100-phon contour and the closest to the linear or un-weighted value.

1 Introduction

1.1 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 a new pizza oven extract fan, a new ventilation stack complete with a 'roof hood' terminal.

The Pizzeria is a restaurant containing a pizza oven with a basic canopy and extract system. The existing exhaust point is via an existing louvre on the North elevation. The new extract fan will provide code compliant ventilation arrangement. There is an office with windows facing the plant area within close proximity to the extract fan and residential receivers opposite, as illustrated in Figure 1—1.

1.2 Site Description

The proposed ventilation terminal will be an additional piece of equipment to the existing kitchen ventilation plant located on the rooftop of the West side of the Museum. The plant location is indicated on the annotated aerial image displayed in Figure 1—1.

The plant noise assessment within this report considers the potential noise impact from the extract fan on the Noise Sensitive Receivers shown in Figure 1—1, as well as potentially on the neighbouring British Museum offices space.

1.3 Scope of Work

The assessment details the potential noise impact of mechanical plant and equipment installation proposals upon existing noise sensitive receptors (NSRs) and the British Museum itself. In summary, the report includes the following:

- Description of the proposed development and site
- 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).

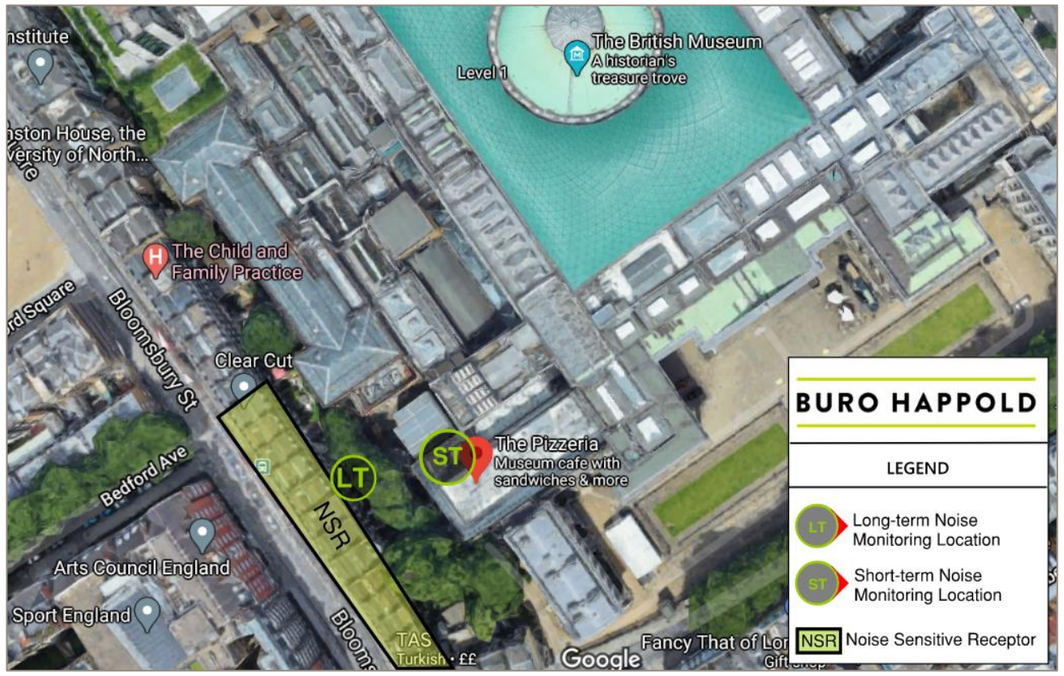


Figure 1—1 Annotated aerial site image illustrating plant location (Source: Google Earth @2020Google)

Figure 1—2 Interior of The Pizzeria

2 Acoustic Criteria

2.1 Noise Survey Guidance Documentation

Buro Happold were appointed by the British Museum to conduct an acoustic noise survey. This was undertaken with reference to 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.
- IS0 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"

2.1.1 Noise Survey Requirements

Shown in Figure 2—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.

2.2 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.
- British Standard (BS) 8233:2014 – Guidance on sound insulation and noise reduction for buildings

In the *Camden Local Plan, 2017* Policy A4 (shown in Figure 2—2) provides a summary of the Noise and Vibration aims for the local planning authority.

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 2—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:

a. development likely to generate unacceptable noise and vibration impacts; or
b. 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 2—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)

2.2.1 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 2—3, Camden council summarise this guidance into 3 basic design criteria of Green, Amber and Red colour coding.

2.2.2 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 be limited to 10 dB below the existing background noise level ($L_{A90,T}$ dB(A)) to be considered acceptable. A further requirement at night is for no plant to exceed a 57 dB(A) L_{Amax} noise level.

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 Figure 2—4, the target for new British Museum plant item is to achieve a green or amber noise impact rating (LOAEL to SOAEL 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).

2.2.3 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 noise criteria of no more than 10 dB above the background level ($L_{A90,15\ mins}$). 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.

2.2.4 British Standard 8233

BS 8233:2014 provides guidance for internal ambient noise levels (IANL) in non-domestic buildings. 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 façade 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 (45-50 dBA for open plan offices), plant should therefore be designed to achieve $\leq L_{Aeq,T}$ 65 dBA at 1 m 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 2—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 9dB 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 57dBL_{Amax}	'Rating level' between 9dB 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 88dBL_{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 2—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)

3 Environmental Noise Survey

3.1 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 Friday 18 September 2020. The aim of the short-term measurements was to understand the noise levels produced by existing plant in and around the substation, whilst the long-term measurement captured the baseline noise levels at nearby noise-sensitive receivers.

3.2 Noise Measurement Locations

The Pizzeria noise measurement locations are detailed below and marked on the annotated aerial image in Figure 3—1 and in Figure 3—2:

- ST1 – Short-term (5 minute) noise measurements conducted on the roof, measuring extract fan noise 1 m from the smoke exhaust point.
- ST2 – Short-term (1 hour) noise measurement conducted at edge of roof
- ST3 – Short-term (5 minute) noise measurement conducted on the roof measuring the other (non-Pizzeria) plant.
- LT1 – Long-term (24 hour) noise measurement positioned by existing NSRs to capture the baseline noise climate including night-time periods. It is noted that some receiver windows are elevated and therefore closer to the plant compound than the measurement position. The measurement position was taken in a semi-sheltered ground floor level location, considered to be indicative of the most onerous (i.e. lowest) LA90,T values in the vicinity of the NSRs. This makes the assessment robust and conservative.

3.2.1 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 3—1 Noise survey instrumentation

Instrumentation	Model No.	Serial Number
Sound Level Meter	RION NL-52	01265411
Acoustic Calibrator	CEL type 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.

3.2.2 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.

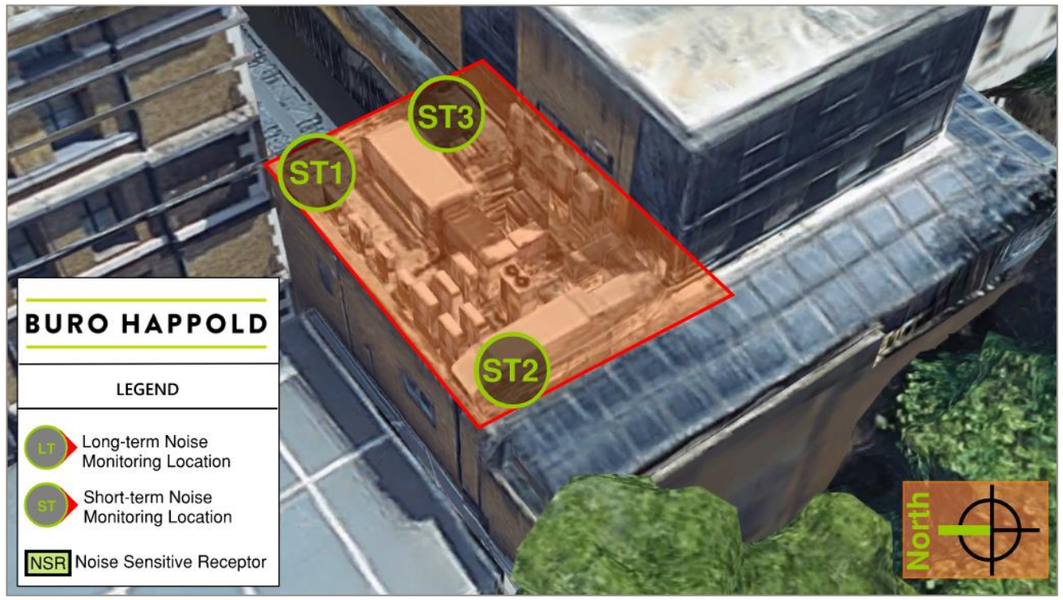


Figure 3—1 Annotated aerial image indicating the noise survey short-term measurement locations (Source: Google Earth, @2020Google).

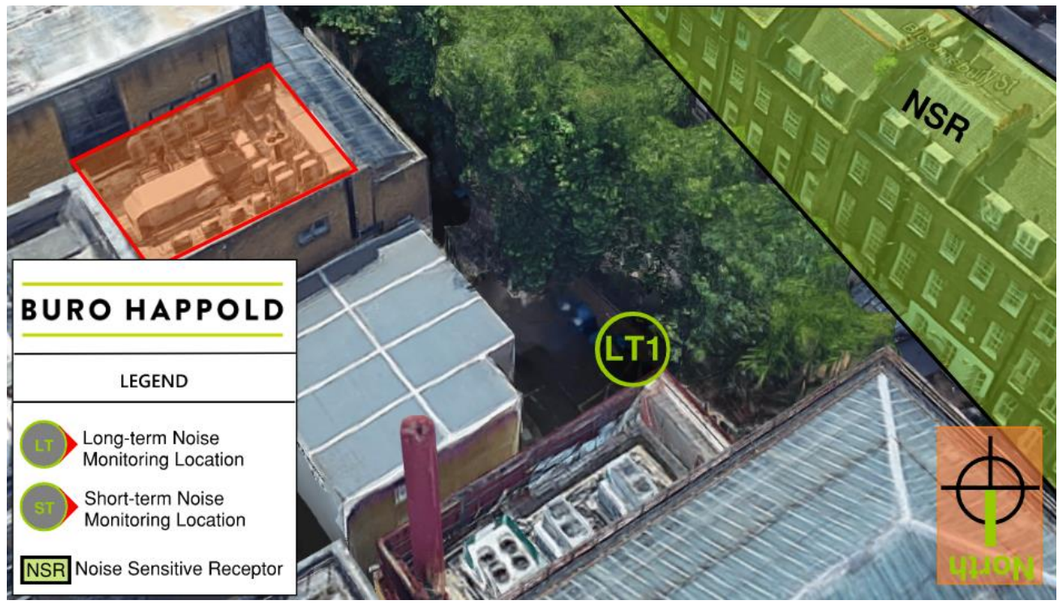


Figure 3—2 Annotated aerial image indicating the noise survey short-term measurement locations (Source: Google Earth, @2020Google).

3.3 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.

3.4 Noise Survey Discussion

On-site attended noise measurements at ST1, ST2, and ST3 (Figure 3—1), provide an indication of the noise emissions from existing plant located in the vicinity of the new proposal. The noise levels recorded, in part due to the plant items, represent the worst-case scenario.

Near The Pizzeria plant ST1, Table 3—2 shows noise levels up to $L_{Aeq,5min}$ 69 dB(A) were recorded at a 1 metre distance from the smoke exhaust.

Near The Pizzeria plant ST2, Table 3—3 noise levels up to $L_{Aeq,1h}$ 63 dB(A) were recorded at the edge of the roof, the side closest to the neighbouring residences (NSRs).

Near non-Pizzeria plant ST3, Table 3—4 shows a noise level of up to $L_{Aeq,5min}$ 79 dB(A) was recorded at a 1 metre distance from a notably noisy exhaust fan (understood to be the Court Café extract). It is notable that the existing Pizzeria exhaust fan does not generate the highest levels of the various rooftop plant items, e.g. compared to this nearfield measurement of another fan outlet.

Near the neighbouring residences (NSRs), Table 3—5 shows a background sound level of 51/49 dB(A) $L_{A90,15min}$ for daytime/night-time respectively was recorded. This measurement was taken at a sheltered location on the site boundary – it may be that the level at higher elevations is actually greater than that measured, due to the reduced distance between the rooftop plant compound and residential windows on upper elevations. However, obtaining a level in a much more sheltered position provides a worst-case scenario assessment and increases robustness.

Table 3—2 Noise survey results at short-term measurement location 1 (ST1)

Measurement Date	Time Period	$L_{Aeq,5min}$ dB(A)	$L_{A90,5min}$ dB(A)	$L_{AF,max}$ dB(A)
15/09/2020	11:11-11:16	69	68	74
	11:16-11:21	68	67	69

Table 3—3 Noise survey results at short-term measurement location 2 (ST2)

Measurement Date	Time Period	$L_{Aeq,1h}$ dB(A)	$L_{A90,1h}$ dB(A)	$L_{AF,max}$ dB(A)
15/09/2020	11:25-11:40	63	63	66
	11:40-11:55	63	62	68
	11:55-12:10	62	61	70
	12:10-12:25	63	62	78

Table 3—4 Noise survey results at short-term measurement location 3 (ST3)

Measurement Date	Time Period	$L_{Aeq,5min}$ dB(A)	$L_{A90,5min}$ dB(A)	$L_{AF,max}$ dB(A)	Notes
15/09/2020	12:30-12:35	79	78	80	This portion of equipment was subjectively very noisy when nearby, though decreased significantly when moving to the back of the equipment, closer to location ST1.

Table 3—5 Noise survey results and highlighted design levels at long-term measurement location 1 (LT1)

Measurement Date	Time Period	$L_{Aeq,15min}$ dB(A)	$L_{A90,15min}$ dB(A)	Notes
17/09/2020	16:00-22:59	58	51	Daytime noise measurement
17-18/09/2020	23:00-06:59	51	49	Night-time noise measurement
18/09/2020	07:00-16:00	57	51	Daytime noise measurement

4 Plant Noise Impact Assessment

4.1 Introduction

The noise generated by the new roof hood must be limited to levels given in policy detailed within the *Camden Local Plan, 2017* (detailed in Section 2).

New British Museum plant items must achieve a rating level ($L_{Ar,Tr}$ noise level including BS 4142 characteristic penalties) of -10 dB compared to the background noise level at the curtilage of NSRs during both daytime and night-time periods. The plant must also not exceed 57 dB(A) $L_{F,max}$ during night-time periods (23:00 – 07:00). It is noted that the British Museum's opening hours are 10:00-17:00 and therefore the Pizzeria extract fan will not be operational at night.

In-situ background noise level measurements and plant noise limits at nearby sensitive receivers are shown in Table 4—1 and Table 4—2.

4.2 Extract Plant Proposal

It is understood that the Nuaire ESBHS5-E extract fan unit has been proposed for installation, in place of the existing plant compound extract fan unit. The octave band sound power levels (as received from Nuaire, the manufacturer) used in the noise impact assessment have been reproduced in Table 4—3. The level provided is:

- **The induct outlet octave band sound power levels** – these are taken to be the sound power level on the atmosphere-side of the extract fan. Schematics received show that there will be a run of ductwork proposed after this point, and therefore the losses due to end reflection, duct attenuation and directivity have been factored into calculations. The ductwork plan can be found in Appendix A and the calculations are summarised in Appendix B.

In addition to the extract fan, a Lindab HN roof hood will be installed for ventilation to the outdoors. The sound power level of the roof hood due to air velocity and pressure as air leaves the hood is L_{WA} 57 dB(A) as seen in Figure 4—1, based on the predicted pressure, velocity, and diameter of the chosen product.

Table 4—1 Measured background noise levels and limiting plant noise levels at nearby sensitive receivers

Noise Sensitive Receiver	Typical measured daytime background noise $L_{A90,15min}$ dB(A) (07:00-23:00)	Plant daytime rating limit $L_{Ar,Tr}$ dB(A) (07:00-23:00)	Typical measured night-time background noise $L_{90,15min}$ dB(A) (23:00-07:00)	Plant night-time rating limit $L_{Ar,Tr}$ dB(A) (23:00-07:00)
		LOAEL		LOAEL
Neighbouring residences	51	41	49	39

Table 4—2 Limiting plant noise levels for open offices from BS 8233, Table 2

Noise Sensitive Receiver	BS 8233: Internal ambient noise level - $L_{Aeq,T}$ dB(A)	BS 8233: Plant rating limits - External: $L_{Ar,Tr}$ dB(A) 1 m from façade
British Museum open office space	45-50	60-65

Table 4—3 Nuaire ESBHS5-E extract fan plant unit sound power data (Source: Nuaire Summary Fan Data Sheet)

Plant Unit		Sound Power Level (dB) at octave band centre frequencies (Hz)							
		63	125	250	500	1K	2k	4k	8k
Nuaire ESBHS5-E	Induct Outlet	92	86	78	74	62	58	53	49

Technical data

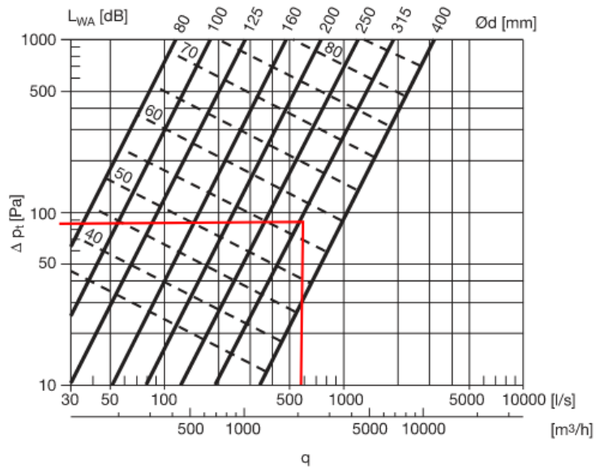


Figure 4—1 Technical specifications of Lindab HN Roof Hood (Source: Lindab Summary Roof Hood Data Sheet)

4.3 Noise Impact Discussion

The sound pressure level generated by the new extract fan is a product of the noise due to the induct outlet and the noise created from air escaping the vent. The sound pressure level at the closest NSR is calculated to be $L_{Aeq,T}$ 26 dB(A), which is 23 m distance from the plant.

At the nearest office window in the British Museum, which is 14 m from the source, the sound pressure level is calculated to be $L_{Aeq,T}$ 30 dB(A) at 1 m from the façade.

These levels will be corrected and compared to targets in the following sections.

4.4 Rating Level

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

4.4.1 Tonality

Noise associated with ventilation 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.

4.4.2 Impulsivity

Fans do not typically have any features which rapidly interrupt the sound generation. On this basis, no corrections for impulsivity are considered to be required.

4.4.3 Intermittency

The extract ventilation unit will run continuously for the time in which the Pizzeria is occupied. On this basis, no correction will be applied for intermittency.

4.5 Summary Table – Rating Level

Table 4—5 shows the specific sound level, corrected for the various features given above to obtain the rating level required in BS 4142.

Table 4—4 Calculated levels of the new extract fan and target plant rating limit at the closest receivers

Noise Sensitive Receiver	Calculated - dB(A)
Neighbouring residence	26
British Museum open office space	30

Figure 4—2 Distance to nearest NSRs

Table 4—5 Rating level required in BS 4142

Value	Correction dB	Level dB(A) at NSR	Level dB(A) at BM Facade
Baseline specific sound level	-	26	30
Tonality correction	+ 0	26	30
Impulsivity correction	+ 0	26	30
Intermittency correction	+ 0	26	30
Rating level $L_{Ar,Tr}$		**26**	**30**

4.6 Assessment – At Nearest NSRs

As can be seen from the tables above, and the calculations in Appendix B, the predicted rating level at the nearest noise-sensitive NSR windows is calculated to be $L_{Ar,Tr}$ 26 dB(A). This more than 10 dB below the background sound level measured during the day, of $L_{A90,15mins}$ 51 dB(A).

As a guideline, BS 4142 states that:

- A difference (between the background and rating level) of around +10 dB or more is likely to be indicative of significant adverse impact, depending on context
- A difference (between the background and rating level) of around +5 dB or more is likely to be indicative of adverse impact, depending on context
- The lower the rating level relative to the background level, the less likely it is that the specific sound will have an adverse impact
- Where the rating level does not exceed the background level, this is an indication that the specific sound will have a low impact, depending on context

In this instance, the level of impact is 10 dB below the background level, and therefore this is taken to be an indication that the specific sound will have a low impact.

In terms of context, it is noted that the background sound level used in assessment is highly pessimistic, being measured in a sheltered location, whereas the upper elevations of the NSR may be much more exposed to existing plant noise. This strengthens the assertion that the impact of the new ventilation arrangement is expected to be negligible.

4.7 Assessment – At British Museum Office Façade

It is generally accepted that an elevation with an open window is capable of providing a sound reduction of approximately 15 dB (e.g. as quoted in BS 8233). The $L_{Ar,Tr}$ predicted on the office façade is 30 dB(A).

Subsequently, when adding the correction for a façade with an open window (inside to outside), the sound pressure level within the open office space is predicted to be $L_{Aeq,T}$ 15 dB(A).

As can be seen from Section 2, the target for open-plan offices in BS 8233 is for an internal noise level of $L_{Aeq,T}$ 45-50 dB(A) and therefore the level of plant noise break in due to the proposed ventilation terminal location is not predicted to be problematic in this regard.

5 Conclusions

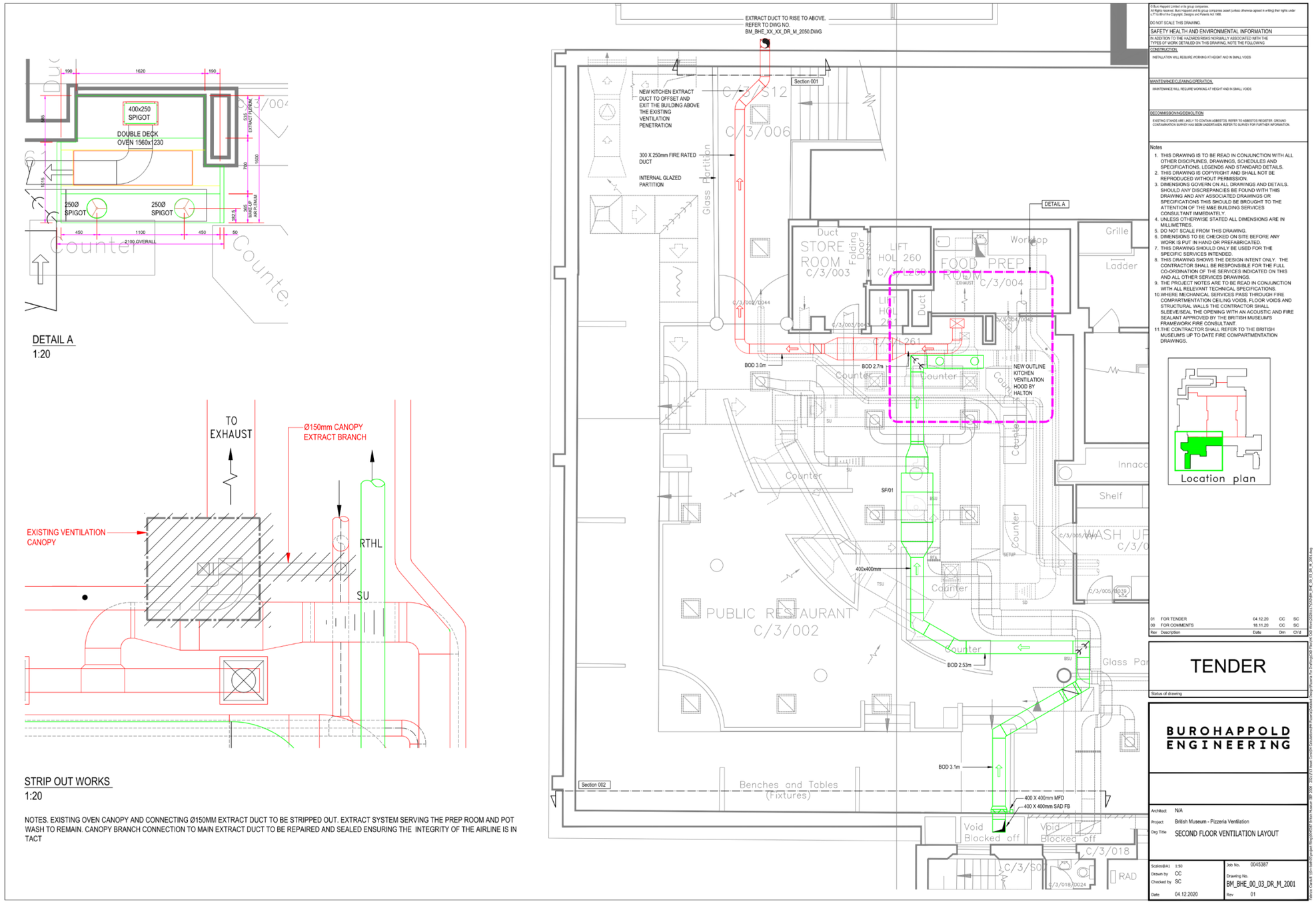
Limiting plant noise levels have been set to achieve suitable levels at a point 1 m from the sensitive façades, at NSRs and the British Museum open plan office space – respectively located at 23 m and 14 m distances from the plant compound.

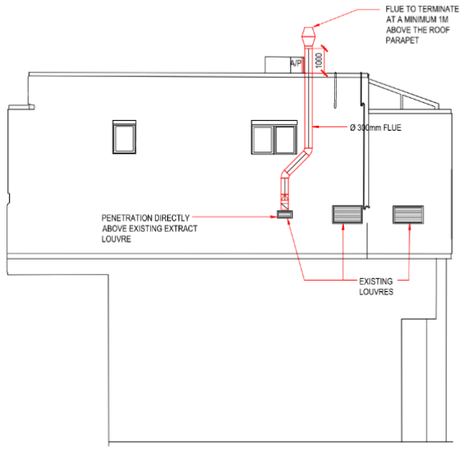
The noise impact of installing of the Nuaire ESBHS5-E extract fan unit and Lindab HN roof hood were assessed against the following design criteria:

- 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).
- To attain the BS 8233:2014 internal ambient noise levels, designing the plant to achieve 65 dB(A) 1 m from the office façade.

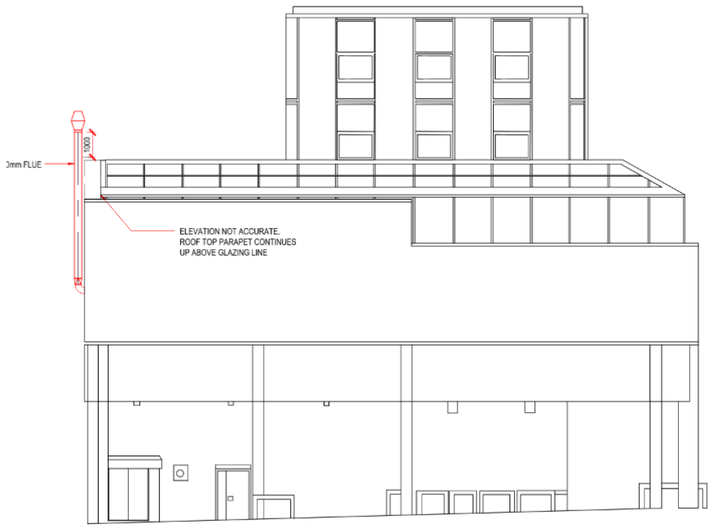
Based on the criteria above, the noise breakout assessment identified that he proposed extract fan plant is likely to mee these targets, maintain the residential amenity and also not providing an unreasonably intrusive level in office accommodation nearby.

Appendix A New Extract Plan





North



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INSTALLATION WILL REQUIRE WORKING AT HEIGHT AND IN SMALL VOIDS

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MAINTENANCE WILL REQUIRE WORKING AT HEIGHT AND IN SMALL VOIDS

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EXISTING STANDS ARE LIKELY TO CONTAIN ASSESTOS. REFER TO ASSESTOS REGISTER. GROUND CONTAMINATION SURVEY HAS BEEN UNDERTAKEN. REFER TO SURVEY FOR FURTHER INFORMATION.

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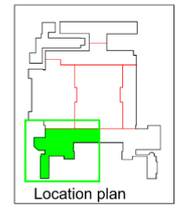
9. THE PROJECT NOTES ARE TO BE READ IN CONJUNCTION WITH ALL RELEVANT TECHNICAL SPECIFICATIONS.
10. WHERE MECHANICAL SERVICES PASS THROUGH FIRE COMPARTMENTATION CEILING VOIDS, FLOOR VOIDS AND STRUCTURAL WALLS THE CONTRACTOR SHALL SLEEVE/SEAL THE OPENING WITH AN ACOUSTIC AND FIRE SEALANT APPROVED BY THE BRITISH MUSEUM'S FRAMEWORK FIRE CONSULTANT.
11. THE CONTRACTOR SHALL REFER TO THE BRITISH MUSEUM'S UP TO DATE FIRE COMPARTMENTATION DRAWINGS.



Rev	Description	Date	Drn	Chkd
01	FOR TENDER	04.12.20	CC	SC
00	FOR COMMENTS	18.11.20	CC	SC

TENDER

Status of drawing

BUROHAPPOLD ENGINEERING

Architect N/A
Project British Museum - Pizzeria Ventilation
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Drawn by CC
Checked by SC
Date 04.12.2020

Job No. 0045387
Drawing No. BM_BHE_XX_XX_DR_M_2050
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Appendix B Plant Noise Break-Out to Atmosphere Calculations

15/01/21	0045387	0045387	SAM

BURO HAPPOLD Acoustics — Plant noise break-out to atmosphere

Grey cells **MUST** be filled in / changed for EACH calculation.

Blue cells can be filled in as an option if required. These relate to attenuation due to known distances, dims, branches and terminations of ductwork, as well as known insertion losses of attenuators and known NR requirements for the room.

CALCULATING SOUND POWER TO THE OUTLET

	m^3/s			SWL	63	125	250	500	1k	2k	4k	8k	Notes
Fan Duty:	1			Spectrum	92	86	78	74	62	58	53	49	Spectrum data in "Main" tab
Type	Index	Mtrs/No. off		Dimension									
Rectangular Duct	RECT DUCT	10.66		300	5	7	5	4	2	2	2	2	Build the ductwork path based on the schematics you have
Circular Duct	CIRC DUCT	6		300	0	1	1	1	1	1	1	1	
Mitre Bend	M.BEND	2		300	0	0	2	14	14	8	6	6	
	Grille size:	24806.25	mm X 3.142 mm		Grille location:		1	Free Space					select the grill location from the drop down box
	End Reflection Loss:		0.077928834	m^2	15	10	5	2	0	0	0	0	Proportion of sound energy reflected back down the ductwork
	Sound Power Leaving:				71	68	65	53	44	46	43	39	The SWL leaving the ductwork

Sound Power to Outlet:	1	m^3/s	100	%	0	0	0	0	0	0	0	0	Expressed as a quantity of duty, in m3 per sec and refers to number of outlets. E.g if fan duty is 1m3/s and has 2 outlets, sound power to each outlet is 0.5m3/s
Distance to Listener:	23			m	-38	-38	-38	-38	-38	-38	-38	-38	Distance between the outlet and the listener (m)
Directivity Factor:		0.077928834		m^2	0	1	3	5	7	8	8	8	Uses free area of the grille size and the location of grille
Direct SPL:					33	31	30	20	13	16	13	9	Calculated SPL at rescptor (linear)
Resultant SPL:					**33**	**31**	**30**	**20**	**13**	**16**	**13**	**9**	
dBA Correction:					-26	-16	-9	-3	0	1	1	-1	A-weighting
A-Weighted Equivalent:					7	15	21	17	13	17	14	8	A-weighted values
1. Induct Outlet Resultant dBA Level (with no attenuation):					25							dBA	
2. Roof Hood Resultant dBA Level (with no attenuation):					19							dBA	
Total Resultant (1+2) dBA Level (with no attenuation):					26							dBA	

Figure B – 1 Noise break-out to atmosphere calculation for NSR with distance to listener set as distance to the façade of the nearby residence

15/01/21	0045387	0045387	SAM

BURO HAPPOLD Acoustics — Plant noise break-out to atmosphere

Grey cells **MUST** be filled in / changed for EACH calculation.

Blue cells can be filled in as an option if required. These relate to attenuation due to known distances, dims, branches and terminations of ductwork, as well as known insertion losses of attenuators and known NR requirements for the room.

CALCULATING SOUND POWER TO THE OUTLET

	m^3/s			SWL	63	125	250	500	1k	2k	4k	8k	Notes
Fan Duty:	1			Spectrum	92	86	78	74	62	58	53	49	Spectrum data in "Main" tab
Type	Index	Mtrs/No. off		Dimension									
Rectangular Duct	RECT DUCT	10.66		300	5	7	5	4	2	2	2	2	Build the ductwork path based on the schematics you have
Circular Duct	CIRC DUCT	6		300	0	1	1	1	1	1	1	1	
Mitre Bend	M.BEND	2		300	0	0	2	14	14	8	6	6	
	Grille size:	24806.25	mm X 3.142	mm	Grille location:		1	Free Space					select the grill location from the drop down box
	End Reflection Loss:		0.077928834	m^2	15	10	5	2	0	0	0	0	Proportion of sound energy reflected back down the ductwork
	Sound Power Leaving:				71	68	65	53	44	46	43	39	The SWL leaving the ductwork

Sound Power to Outlet:	1	m^3/s	100	%	0	0	0	0	0	0	0	0	Expressed as a quantity of duty, in m3 per sec and refers to number of outlets. E.g if fan duty is 1m3/s and has 2 outlets, sound power to each outlet is 0.5m3/s
Distance to Listener:	14			m	-34	-34	-34	-34	-34	-34	-34	-34	Distance between the outlet and the listener (m)
Directivity Factor:		0.077928834		m^2	0	1	3	5	7	8	8	8	Uses free area of the grille size and the location of grille
Direct SPL:					37	35	34	25	17	20	17	13	Calculated SPL at rescptor (linear)
Resultant SPL:					**37**	**35**	**34**	**25**	**17**	**20**	**17**	**13**	
dBA Correction:					-26	-16	-9	-3	0	1	1	-1	A-weighting
A-Weighted Equivalent:					11	19	25	22	17	21	18	12	A-weighted values
1. Induct Outlet Resultant dBA Level (with no attenuation):					29							dBA	
2. Roof Hood Resultant dBA Level (with no attenuation):					23							dBA	
Total Resultant (1+2) dBA Level (with no attenuation):					30							dBA	

Figure B – 2 Noise break-out to atmosphere calculation for open office with distance to listener set as distance to the façade of the British Museum open office

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