Project: J 02766
Noise Impact Assessment:
84 Chancery Lane, Camden

Consultants: Sound Planning Ltd
48 Windermere Way
Farnham
Surrey
GU9 0DE

[

Client: Stiles, Harold, Williams Partnership

Prepared by: D. M. Thomas

Signed:

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Acoustic Consultant

Dated: Thursday 22nd December 2016

CONTENTS

1.0 BACKGROUND

1.1 Planning permission is sought for the installation of an air conditioning, ventilation and heat recovery system at 84 Chancery Lane, London WC2A 1DL.

See APPENDIX 2 – Site Location/Plans

1.2 The location falls under the jurisdiction of the London Borough of Camden; a noise impact assessment should be carried out in accordance with their Unitary Development Plan (UDP).

1.3 The proposed systems include:

- Daikin VAM1000FC (Ventilation and Heat Recovery System) [3 units]
- Daikin RX20K (External Condenser Unit for Air Conditioning)

1.4 The Daikin RX20K (condenser unit) and 1 Daikin VAM1000FC (heat recovery system) are located to a rear plant room area (Star Yard); and the other 2 Daikin VAM1000FC units are located to the ceiling of the main Bar/Lounge area to the front of the building (Chancery Lane).

See APPENDIX 2 – Site Location/Plans and APPENDIX 3 - Site Photographs

1.5 Sound Planning has been retained to evaluate potential noise impact on the nearest noise sensitive receivers using appropriate methodologies and assessment criteria and design a suitable noise mitigation strategy.

1.5.1 Participating Acoustic Consultant

Dan Thomas is a Member of the Institute of Acoustics (M.I.O.A) having attained appropriate qualifications in acoustics and experience within the workplace.

1.5.2 Qualifications

Dan has been working within the noise and vibration industry for ten years and has attained the following qualifications within the field of acoustics:

- Institute of Acoustics (IOA) Diploma
- Post Graduate Diploma in Applied Acoustics and Noise Control (University of Surrey)

- Masters Degree in Applied Acoustics and Noise Control (University of Surrey)

2.0 ASSESSMENT CRITERIA

2.1 Noise emissions from mechanical plant should be assessed in accordance with the requirements of the Local Planning Authority; and relevant national standards:

2.2 BS 4142: 1997[1,2]

2.2.1 Noise from industrial sources radiated to residential areas is usually assessed against British Standard BS 4142: 1997, `*Method for rating industrial noise affecting mixed residential and industrial areas'*. This standard describes a method for assessing whether the `specific noise' from an industrial source is likely to give rise to complaints from residents of the adjacent dwellings.

2.2.2 The `specific noise' levels are determined outside dwellings. The specific noise level is determined for reference time periods of 1 hour for the *daytime* (07:00 to 23:00) and 5 minutes for the *night time* (23:00 to 07:00). Tonal or impulsive characteristics of a noise are likely to increase the scope for complaints and this taken into account by adding +5dB to the specific noise source level to obtain the `Rating Level'. BS 4142: 1997 requires that the Rating Level of a noise is compared with the existing background noise: ($L_{A90, T}$).

2.2.3 Guidance given in the standard states that if the difference between the Rating Level and the background noise ($L_{A90, T}$) is +5dB, it would be considered as being of *marginal significance*. This is usually taken as being an acceptable situation, as it is a reasonable compromise between the requirements of commerce and the amenity of residents.

2.2.4 A difference of around +10dB or more indicates that *complaints are likely*. Most Local Authorities use a difference of +10dB as the point at which they will take action against the organisation producing the noise.

2.2.5 If the Rating Level is more than 10dB below the background noise this is a positive indication that *complaints are unlikely.*

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[1] British Standard 4142: 1997 – *Method for rating industrial noise affecting mixed residential and industrial areas*. © BSI 1997. ISBN 0 580 28300 3.

[2] Superseded by BS 4142: 2014.

2.3 British Standard 4142: 2014.[3]

2.3.1 BS 4142: 2014 – Scope

This British Standard describes methods for rating and assessing sound of an industrial and/or commercial nature, which includes:

a) sound from industrial and manufacturing processes;

b) sound from fixed installations which comprise mechanical and electrical plant and equipment;

c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises; and

d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site.

The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

This standard is applicable to the determination of the following levels at outdoor locations:

a) rating levels for sources of sound of an industrial and/or commercial nature and

b) ambient, background and residual sound levels, for the purposes of:

- investigating complaints;
- assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature; and

[3] British Standard 4142: 2014 – Methods for rating and assessing industrial and commercial sound.

- assessing sound at proposed new dwellings or premises used for residential purposes.

2.3.2 BS 4142: 2014 – Assessment of Impacts

The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs.

Evaluation of Adverse Impact

- 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 is likely to 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 the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

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

2.4 Noise Measurement Protocol - British Standard 7445-1: 2003[4]

2.4.1 The methods and procedures described in BS 7445 are intended to be applicable to sounds from all sources, individually and in combination, which contribute to the total noise at a site.

[4] Description and measurement of environmental noise. Part 1 – Guide to quantities and procedures.

2.4.2 The aim of the BS 7445 series is to provide authorities with material for the description of noise in community environments. Based on the principles described in this standard, acceptable limits of noise can be specified and compliance with these limits can be controlled.

2.4.3 BS 7445 does not specify limits for environmental noise.

2.5 Camden Replacement Unitary Development Plan (UDP)

2.5.1 *The Council will only grant planning permission for plant or machinery, including ventilation or air handling equipment, if it can be operated without causing a loss to local amenity and does not exceed the thresholds set out in Appendix 1 - Noise and Vibration (Table E).*

2.5.2 Noise levels from plant and machinery at which planning permission will not be granted[5].

Noise description and location of measurement	Period	Time (hours)	Noise Level
Noise at 1 metre external to a sensitive façade	Day, evening and night	0000 - 2400	5dB(A) $< L_{A90}$
Noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) at 1 metre external to a sensitive façade	Day, evening and night	0000 - 2400	10dB(A) $< L_{A90}$
Noise that has distinct impulses (bangs, clicks, clatters, thumps) at 1 metre external to a sensitive façade	Day, evening and night	0000 - 2400	10dB(A) $< L_{A90}$
Noise at 1 metre external to a sensitive façade where $L_{A90} > 60$dB	Day, evening and night	0000 - 2400	55dB L_{Aeq}

[5] Camden Replacement Unitary Development Plan. Appendix 1 – Noise and Vibration Thresholds.

2.6 British Standard 8233: 2014[6]

2.6.1 BS 8233: 2014 is the *Guidance on sound insulation and noise reduction for buildings – Code of practice*.

2.6.2 Indoor Ambient Noise Levels for Dwellings

Activity	Location	Design Range dB $L_{Aeq, T}$
Study and work requiring attention	Staff/meeting room, training room	35 - 45
	Executive Office	35 - 40

2.7 CIBSE - Building Services Noise

2.7.1 Guide B provides guidance on the practical design of heating, ventilation and air conditioning systems. It represents a consensus on what constitutes relevant good practice guidance.

2.7.2 This document, which forms chapter 4 of CIBSE Guide B, provides guidance to building services engineers and others involved in the design of building services on the generation, prediction, assessment and control of noise and vibration from building services, so that designers may produce systems which meet acceptable noise limits.

2.7.3 Recommended Noise Ratings for Internal Areas

CIBSE has published a table of acceptable noise rating level relative to internal environment.

Please refer to APPENDIX 8 - CIBSE NR Table

[6] Supersedes BS 8233: 1999.

3.0 METHODOLOGY

3.1 Existing Noise Climate

84 Chancery Lane is busy London street with a number of restaurants, bars and night clubs (open until 3am weekends).

See APPENDIX 2 – Site Location/Plans

3.2 Background Noise Assessment

3.2.1 A manned background noise assessment was conducted during the early hours of Thursday 22nd December 2016:

Star Yard (rear façade):	02:26 - 02:41 hours
Chancery Lane (front façade):	02:43 - 02:58 hours

3.2.2 The proposed air conditioning, ventilation and heat recovery system will be operational until 03:00 hours.

3.2.3 The microphone was located as close as possible to the nearest noise sensitive windows [although unknown it would appear as though the nearest windows belonged to commercial offices, with the nearest residential possibly on the 3rd floors].

See APPENDIX 3 – Site Photographs

3.2.4 Measurements were undertaken in accordance with BS 7445[7] and BS 4142[8].

3.2.5 The Sound Level Meter (SLM) used for the assessment is Class 1 with real time octave band measurement capability; and compliant to IEC 61672[9].

3.2.6 The A-weighted L_{90}, L_{eq} and L_{max} descriptors were measured for 15 minute periods using the Fast (F) setting.

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[7] British Standard 7445-1: 2003 – *Description and measurement of environmental noise.* © BSI 1997. ISBN 0 580 19736 0.
[8] British Standard 4142: 1997 – *Method for rating industrial noise affecting mixed residential and industrial areas*. © BSI 1997. ISBN 0 580 28300 3.
[9] International Standard IEC 61672-1: 2002. Electroacoustics – Sound level meters – Part 1: Specifications.

3.3 Instrumentation/Equipment

3.3.1 Equipment

Equipment	Make	Model	Class	Serial Number	UKAS Calibration
SLM	Casella	CEL 490	1	128950	U18565 (16/4/15)
Field Calibrator	Casella	CEL 110/1	1	077948	U18561 (16/4/15)
Environmental Tripod					
Wind/Weather Shield					
Laser Measurer	Leica	Disto A5		1073750838	
Digital Camera	Samsung				

3.3.2 Field Calibration

A field calibration was conducted for the SLM microphone; no significant deviation was detected (1kHz).

UKAS calibration certificates are available on request.

3.3 Duct System Break-Out Calculations

3.3.1 All calculations will utilise the manufacturers' sound power level (SWL) data or calculated SWL based on the fan type, pressure and air volume[10].

3.3.2 The fan sound power level (SWL) will be attenuated by internal system (duct) losses and end reflection on reaching the exhaust termination[11].

[10] Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.
[11] Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.

3.3.3 Duct Break-Out[12] calculations will utilise the formula:

$SWL_{break\text{-}out} = SWL_{duct} – R + 10\log(S/A)$[13]

Where	*SWL*	*Sound Power Level*
	S	*Surface Area (Visible Duct)*
	A	*Cross Section*
	R	*Sound Reduction Index*

The term 'R' cannot give a greater break-out level than there is inside the duct. Therefore at low frequency the effective reduction is taken as 3dB.

3.3.4 The noise level at the nearest external noise sensitive receivers (NSR's) will be calculated using the formula:

$SPL_2 = SPL_1 – 20\log_r – 11 + DI$[14] [point source] and $SPL_2 = SPL_1 – 10\log_r – 11 + DI$ [line source].

Where 'r' = radius; SPL = Sound Pressure Level.

3.3.5 The directionality of the duct opening[15] relative to the receiver should also be considered; the approximate directivity attenuation can be found by comparing fd/c with the angle to the receiver[16].

3.3.6 Screening attenuation is based on Maekawa's formula (if required), where the expected insertion loss the barrier is the function of the Fresnel number $(2.\delta/\lambda)$[17].

3.3.7 Noise mitigation calculations will utilise sound reduction indices or insertion loss data from the manufacturer's specification data sheets.

[12] See APPENDIX 6 – Calculation Tables.
[13] Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.
[14] DI = Directivity Index.
[15] The configuration of the duct termination is currently unknown e.g. cowl etc.
[16] f = frequency; d = duct opening (m); and c = speed of sound 344m/s. Reference: Watson et al. *The Little Red Book of Acoustics*. BTA 2007.
[17] Attenborough, K. et al. *Predicting Outdoor Sound*. Copyright Taylor & Francis Group 2007.

3.4 Plantroom Break-Out Calculations (Condenser Unit in Rear "Plant Room")

3.4.1 Internal Sound Pressure Level: SPL = SWL + 10 log [$(Q_\theta/4\pi r^2)$ + $(4/R_c)$] dB

Where

r	is the distance from the source 'm'
Q_θ	is the directivity factor of the source in the direction of 'r'
R_c	is the room constant $S\bar{\alpha} / (1 - \bar{\alpha})$ m^2 units
S	is the surface area of the room m^2
$\bar{\alpha}$	is the average absorption coefficient in the room
$\bar{\alpha}$	$= (S_1\alpha_1 + S_2\alpha_2 + S_3\alpha_3 + \text{etc...}) / S$
S_1	is the area of the first material within a room/enclosure (S_2 is the second material)
α_1	is the corresponding absorption coefficient of that material
S	is the total surface area of the room m^2

3.4.2 Source Directivity Corrections

Position of Source	Directivity Factor Q_θ	Directivity Index DI dB
Near centre of room	1	0
At centre of wall, floor or ceiling	2	3
Centre of edge formed by junction of two adjacent surfaces	4	6
Corner formed by junction of three adjacent surfaces	8	9

3.4.3 Plant Room Break Out Calculation

$SPL_2 = SPL_1 - R_{av} + 10 \log S_p - 20 \log r - 11 - 6 + DI$ dB

Where

S_p	is the area of the wall m^2
r	is the distance from the wall 'm'
R_{av}	is the average sound reduction index for the complete wall dB

3.4.4 The directionality of the duct opening relative to the receiver should also be considered; the approximate directivity attenuation can be found by comparing fd/c with the angle to the receiver[18].

3.4.5 Screening attenuation is based on Maekawa's formula (if required), where the expected insertion loss the barrier is the function of the Fresnel number $(2.\delta/\lambda)$[19].

A screen just blocking direct line of sight from source to receiver will achieve a 5 dB noise reduction throughout all frequencies.

4.0 RESULTS

4.1 Background Noise Levels

Location	Façade	Time Period (hours)	Background Noise Level dB $L_{A90, 15mins}$
Star Yard	Rear	02:26 - 02:41	43
Chancery Lane	Front	02:43 - 02:58	45

See APPENDIX 5 – Background Noise Levels for full results.

[18] Stroughal Number where f = frequency; d = duct opening (m); and c = speed of sound 344m/s. Reference: Watson et al. *The Little Red Book of Acoustics*. BTA 2007.
[19] Attenborough, K. et al. *Predicting Outdoor Sound*. Copyright Taylor & Francis Group 2007.

4.2 Mechanical Equipment - Sound Pressure Levels[20]

Manufacturer	Model	Sound Level dB(A)		Number of Units
		Power L_w	Pressure L_p	
Daikin	VAM1000FC	53	36	3
Daikin	RX20K	-	47	1

4.3 Meteorological Conditions

Wind Speed/Direction	WSW 1m/s
Likelihood of Temperature Inversion[21]	No - Relatively short distances – Little effect
Precipitation	0 mm
Fog	No
Wet Ground	No
Frozen Ground/Snow Coverage	No
Temperature	8 °C
Cloud Cover	Partial cloud cover

[20] Octave band data sheets - APPENDIX 4.
[21] i.e. Calm night with little cloud cover.

4.5 Levels of Uncertainty

Category	Notes
Complexity of Sound Source	Daikin VAM1000 - Cased unit with 2inlet air and 2 outlet air ducts Daikin RX20K - external condenser unit with front fan pulling air through radiator coil to the rear
Complexity of Acoustic Environment (Residual)	Road Traffic, Mechanical Ventilation, Pedestrians
Level of Residual Sound (including Specific)	n/a
Measurement Locations	Representative of nearest noise sensitive receivers
Distance Between Sound Source & Measurement Position	n/a
Number of Measurements Taken	2 x 15 minutes (front and rear façades)
Measurement Time Intervals	Continuous
Range of Times	Representative of quietest likely times of proposed operation
Range of Suitable Weather Conditions	1 measurement period – Suitable weather conditions
Measurement Method/Practitioners	1 measurement period (Dan Thomas)
Level of Rounding	Rounded to nearest DP; 0.5 rounded up
Instrumentation	Type 1 SLM (suitable)

5.0 NOISE CALCULATIONS[22]

5.1 External Noise Sensitive Receivers (NSR) - Residential

5.1.1 Front Façade (Chancery Lane)

Noise Sensitive Receiver (NSR)	1st Floor Windows[23]
Daikin VAM 1000 Unit 1	28 dB L_{Aeq} @ NSR
Daikin VAM 1000 Unit 2	30 dB L_{Aeq} @ NSR
Total Sound Pressure Level @ NSR	32 dB L_{Aeq}
Background Level	45 dB L_{A90}
Excess over Background	-13 dB(A)
Attenuation required	***No attenuation required***

5.1.2 Rear Façade (Star Yard)

Noise Sensitive Receiver (NSR)	1st Floor Windows
Daikin VAM 1000 Unit 3	47 dB L_{Aeq} @ NSR
Daikin RX20K	41 dB L_{Aeq} @ NSR
Total Sound Pressure Level @ NSR	48 dB L_{Aeq}
Background Level	43 dB L_{A90}
Excess over Background	5 dB(A)
Attenuation required	***15 dB(A)***

[22] See APPENDIX 6 for full calculation tables.
[23] It has been assumed that the nearest noise sensitive windows on the 1st floor are residential in order to establish a worst case.

5.2 Internal Noise Transmission

5.2.1 Separating Floor (Ground - 1st Floor)

Concrete Floor

Daikin VAM 1000 sound pressure level 36 dB L_{Aeq} @ 1m

Residential 1st Floor [possible] 0 dB(A)

6.0 NOISE MITIGATION STRATEGY

6.1 Noise Mitigation Measures

6.1.1 Front Façade Equipment (Chancery Lane)

No noise mitigation measures required.

6.1.2 Rear Façade Equipment (Star Yard) [24]

Equipment/Area	**Noise Control Products**	**Sound Level at Receiver**
		dB(A)
Daikin VAM1000 Unit 3	37.5% Free Area x 600mm (L) Attenuator	30
Daikin RX20K	CAICE SH300 Acoustic Louvre[25]	30
Combined		33
Background		43
Excess		-10

[24] See APPENDIX 6 - Calculation Tables
[25] Replacing weather louvre vent.

6.2 Installation Notes

6.2.1 Silencers (attenuators) should be fitted in duct as close as possible to the fan.

6.2.2 The acoustic louvre should replace the existing window (change of specification from weather louvre originally proposed)

See APPENDIX 3 - Site Photographs

6.3 Acoustic Louvre Suppliers

CAICE	Tel: 01189 186 470

6.4 Silencer/Attenuator Suppliers

CAICE	Tel: 01189 186 470
EMTEC	Tel: 0208 8483031
Various	

7.0 CONCLUSIONS

7.1 Sound Planning has carried out an evaluation of mechanical equipment break-out noise at the nearest noise sensitive receivers (assumed to be nearest 1st floor windows) on both front (Chancery Lane) and rear (Star Yard) façades.

See Section 3.0 - METHODOLOGY

7.2 Predicted equipment sound pressure levels at the nearest (residential) noise sensitive receiver are:

Front (Chancery Lane): 32 dB L_{Aeq}
Rear (Star Yard): 43 dB L_{Aeq}

See Section 5.0 - NOISE CALCULATIONS

7.3 Background noise levels:

Location	Façade	Time Period (hours)	Background Noise Level dB $L_{A90, 15mins}$
Star Yard	Rear	02:26 - 02:41	43
Chancery Lane	Front	02:43 - 02:58	45

See Section 4.0 - RESULTS

7.3 Noise Evaluation

7.3.1 Front Façade (Chancery Lane): *Meets Camden Target Level Thresholds*

7.3.2 Rear Façade (Star Yard): *Does not meet Camden Target Level Thresholds*

See Section 5.0 - NOISE CALCULATIONS

7.4 Camden Noise Target Level Thresholds

An insertion loss (noise reduction) of 15 dB(A) is required in order to comply with Camden's Noise Target Levels for plant to the rear façade.

See Section 2.0 - ASSESSMENT CRITERIA

7.5 Noise Mitigation Measures

In order to meet the target noise criteria at the nearest noise sensitive window the noise mitigation measures detailed within this report should be introduced i.e. Duct silencer and acoustic louvre.

See Section 6.0 - NOISE MITIGATION STRATEGY

APPENDIX 1

Glossary of Acoustic Terms

The Decibel, dB

The unit used to describe the magnitude of sound is the decibel (dB) and the quantity measured is the sound pressure level. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure, which is a characteristic of the ear. Use of a logarithmic scale has the added advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers. The threshold of hearing occurs at approximately 0 dB (which corresponds to a reference sound pressure of 2 x 10^{-5} pascals) and the threshold of pain is around 120 dB. The sound energy radiated by a source can also be expressed in decibels. The sound power is a measure of the total sound energy radiated by a source per second, in watts. The sound power level, L_w is expressed in decibels, referenced to 10^{-12} watts.

Frequency, Hz

Frequency is analogous to musical pitch. It depends upon the rate of vibration of the air molecules that transmit the sound and is measure as the number of cycles per second or Hertz (Hz). The human ear is sensitive to sound in the range 20 Hz to 20,000 Hz (20 kHz). For acoustic engineering purposes, the frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, in which each octave band is divided into three. The bands are described by their centre frequency value and the ranges which are typically used for building acoustics purposes are 63 Hz to 4 kHz (octave bands) and 100 Hz to 3150 Hz (one-third octave bands).

Noise Rating

The Noise Rating (NR) system is a set of octave band sound pressure level curves used for specifying limiting values for building services noise. The Noise Criteria (NC) and Preferred Noise Criteria (PNC) systems are similar.

A-weighting

The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).

Noise Descriptors

Where noise levels vary with time, it is necessary to express the results of a measurement over a period of time in statistical terms. Some commonly used descriptors follow.

$L_{Aeq, T}$ *The most widely applicable unit is the equivalent continuous A-weighted sound pressure level ($L_{Aeq, T}$). It is an energy average and is defined as the level of a notional sound which (over a defined period of time, T) would deliver the same A-weighted sound energy as the actual fluctuating sound.*

L_{AE} *Where the overall noise level over a given period is made up of individual noise events, the $L_{Aeq, T}$ can be predicted by measuring the noise of the individual noise events using the sound exposure level, L_{AE} (or SEL or L_{AX}). It is defined as the level that, if maintained constant for a period of one second, would deliver the same A-weighted sound energy as the actual noise event.*

L_{A1} *The level exceeded for 1% of the time is sometimes used to represent typical noise maxima.*

L_{A10} *The level exceeded for 10% of the time is often used to describe road traffic noise.*

L_{A90} *The level exceeded for 90% of the time is normally used to describe background noise.*

Sound Transmission Descriptors

D_{nT} Standardised level difference

$D_{nT, w}$ Weighted standardised level difference

L_1 The average sound pressure level in the source room

L_2 The average sound pressure level in the receiving room

T Reverberation time (receiving room)

T_0 Reference reverberation time = 0.5s

C_{tr} Adaption spectrum which takes account for low to medium speed road/rail/air traffic; disco music; and factory noise (medium to low frequency noise).

C Adaptation spectrum which takes account of domestic activities including speech, music, radio and television.

Frequency Analysis

Octave Band	*A band of frequencies the upper limit of which is twice the lower limit. They are known by their centre frequency, e.g., 63, 125, 250, 500, 1000, 2000 Hz…*
One Third Octave	*The logarithmic frequency interval between a lower frequency f_2, when f_2/f_1 equals $2^{1/3}$ apart. Frequencies include: 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000Hz.*

Sound Transmission in the Open Air

Most sources of sound can be characterised as a single point in space. The sound energy radiated is proportional to the surface area of a sphere centred on the point. The area of a sphere is proportional to the square of the radius, so the sound energy is inversely proportional to the square of the radius. This is the inverse square law.

In decibel terms, every time the distance from a point source is doubled, the sound pressure level is reduced by 6 dB. Road traffic noise is a notable exception to this rule, as it approximates to a line source, which is represented by the line of the road. The sound energy radiated is inversely proportional to the area of a cylinder centred on the line. In decibel terms, every time the distance from a line source is doubled, the sound pressure level is reduced by 3 dB.

Factors Affecting Sound Transmission in the Open Air

Reflection

When sound waves encounter a hard surface, such as concrete, brickwork, glass, timber or plasterboard, it is reflected from it. As a result, the sound pressure level measured immediately in front of a building façade is approximately 3 dB higher than it would be in the absence of the façade.

Screening and Diffraction

If a solid screen is introduced between a source and receiver, interrupting the sound path, a reduction in sound level is experienced. This reduction is limited, however, by diffraction of the sound energy at the edges of the screen. Screens can provide valuable noise attenuation however. For example, a timber boarded fence built next to a motorway can reduce noise levels on the land beyond, typically by around 10 dB(A). The best results are obtained when a screen is situated close to the source or close to the receiver.

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Meteorological Effects

Temperature and wind gradients affect noise transmission, especially over large distances. The wind effects range from increasing the level by typically 2 dB downwind, to reducing it by typically 10 dB upwind – or even more in extreme conditions. Temperature and wind gradient are variable and difficult to predict.

APPENDIX 2

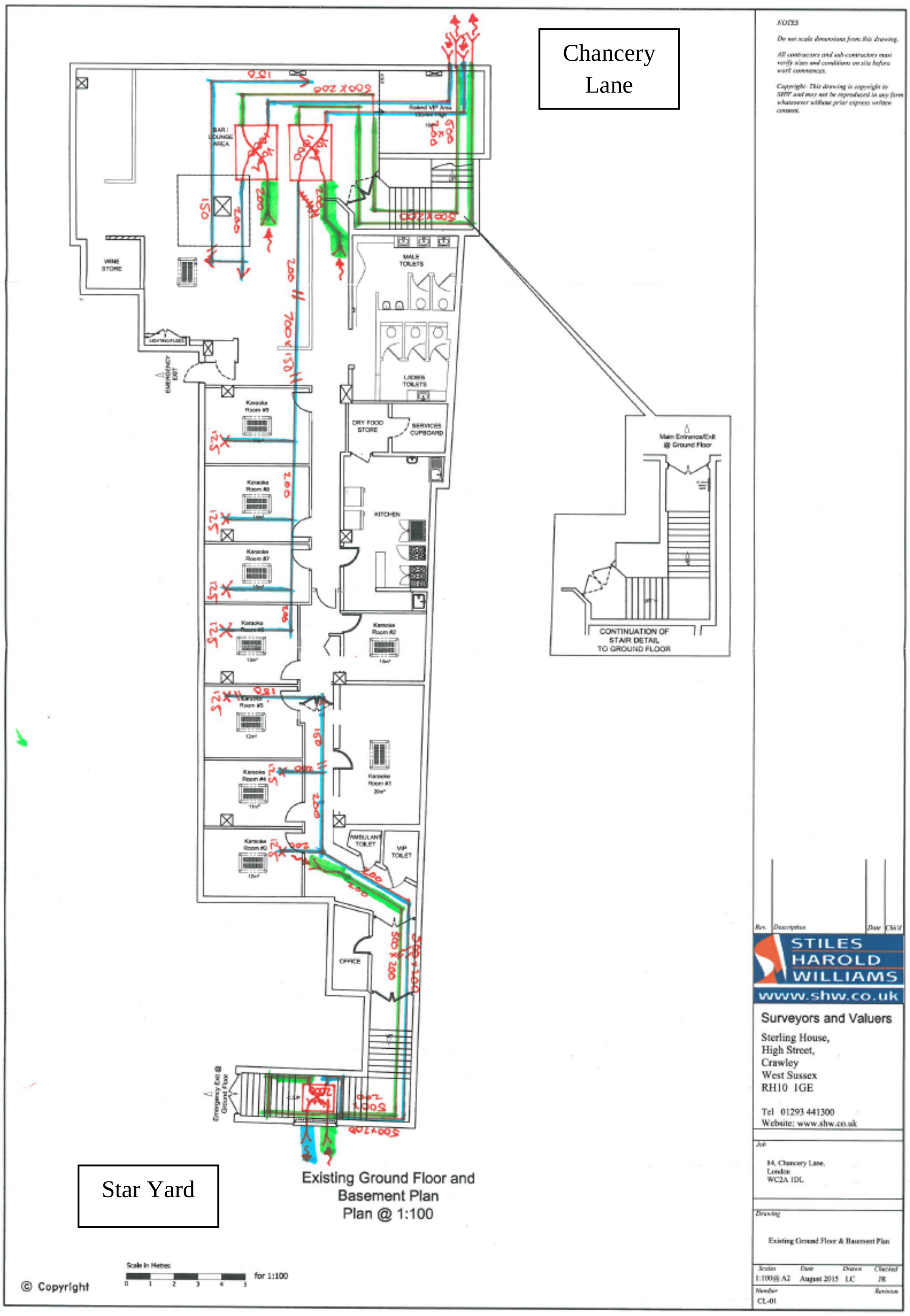
Site Location/Plans

84 Chancery Lane

Google Earth Screenshot

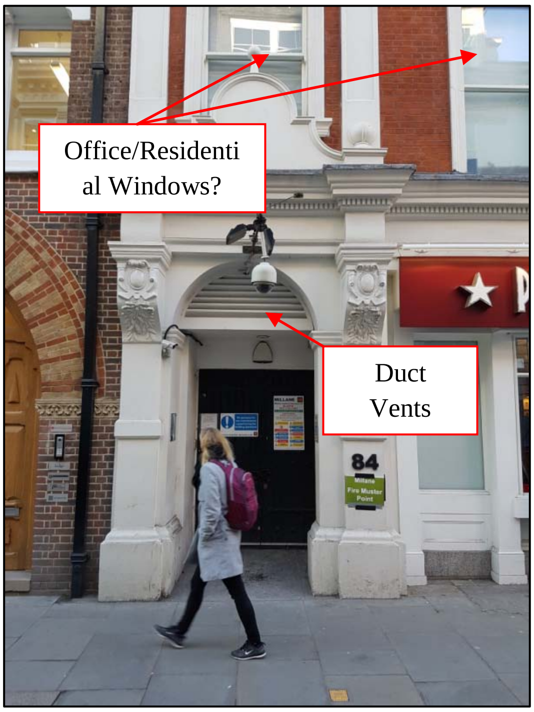
Site Location/Plans

Mechanical Equipment Layout

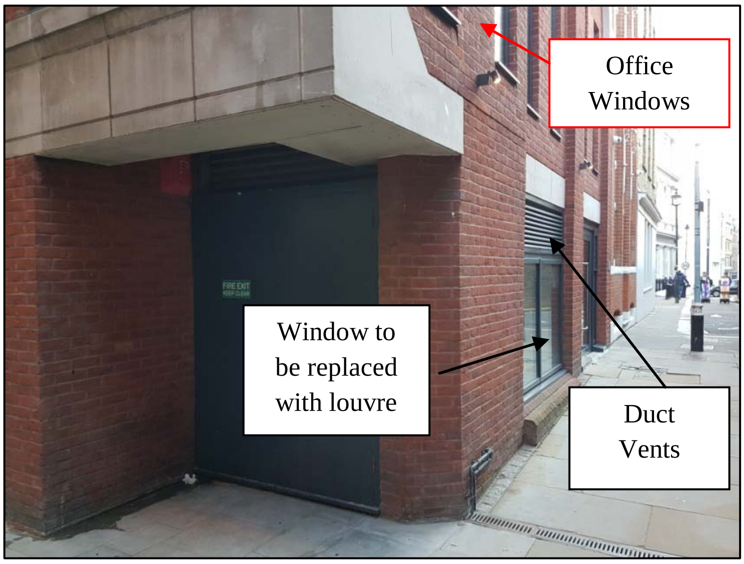


APPENDIX 3

Site Photographs



Front Elevation



Rear Elevation

Site Photographs

Front Elevation - Microphone Position

Site Photographs

Rear Elevation - Microphone Position

APPENDIX 4

Mechanical Equipment

Daikin VAM1000[26]

Sound Power Spectrum

8 Sound data

8 - 1 Sound Power Spectrum

8

VAM800FC

Power level data (in case of Total Heat Exchange mode)

(dB) (dBA)

Unit model name	Hz / Fan speed	63	125	250	500	1000	2000	4000	8000	Total
VAM800FB	U-H	58.0	58.0	52.5	49.5	48.5	41.5	33.5	26.0	53
	H	58.5	57.0	51.5	49.5	47.0	40.5	31.0	27.5	52
	L	54.5	54.5	47.5	44.5	43.0	35.5	24.5	23.5	47

NOTES

1. dBA = A-weighted sound power level (A-scale according to IEC).
2. Reference acoustic intensity 0dB = 10E-6μW/m²
3. Measured according to ISO 3744.
4. The operating sound level may become higher than this value depending on the operating conditions, reflected sound and peripheral noise.
5. The power levels have been calculated in the assumption that the measuring point is immediately under the source of operating sound.

4D082467

VAM1000FC

Power level data (in case of Total Heat Exchange mode)

(dB) (dBA)

Unit model name	Hz / Fan speed	63	125	250	500	1000	2000	4000	8000	Total
VAM1000FB	U-H	62.0	58.5	54.0	50.5	49.0	42.0	36.5	28.0	53
	H	61.0	57.0	52.0	50.0	48.0	38.5	31.0	25.5	52
	L	58.0	55.0	49.0	45.5	43.5	36.5	27.5	24.0	48

NOTES

1. dBA = A-weighted sound power level (A-scale according to IEC).
2. Reference acoustic intensity 0dB = 10E-6μW/m²
3. Measured according to ISO 3744.
4. The operating sound level may become higher than this value depending on the operating conditions, reflected sound and peripheral noise.
5. The power levels have been calculated in the assumption that the measuring point is immediately under the source of operating sound.

4D082468

[26] Source: Daikin Technical.

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Mechanical Equipment

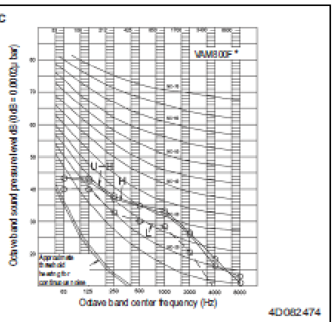
Daikin VAM1000[27]

Sound Pressure Spectrum

8 Sound data

8 - 2 Sound Pressure Spectrum

VAM800FC



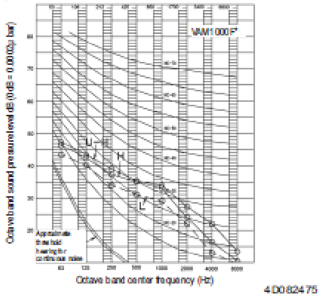
4D082474

Air flow rate (dB)		
U-H	H	L
35.5	34.5	31

NOTES

1. Ventilation mode: total heat exchange.
2. Operation noise is measured in an anechoic chamber.
3. The operation noise level may become higher than this value depending on the operation conditions, reflected sound and peripheral noise.
4. Operation noise differs with operation and ambient conditions.
5. U-H: ultra-high, H: high, L: low
6. Location of microphone.

VAM1000FC



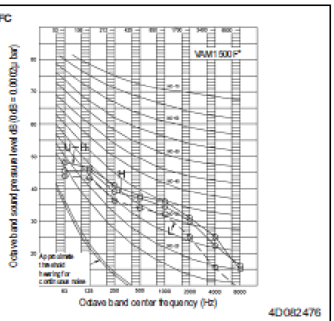
4D082475

Air flow rate (dB)		
U-H	H	L
36	35	31.5

NOTES

1. Ventilation mode: total heat exchange.
2. Operation noise is measured in an anechoic chamber.
3. The operation noise level may become higher than this value depending on the operation conditions, reflected sound and peripheral noise.
4. Operation noise differs with operation and ambient conditions.
5. U-H: ultra-high, H: high, L: low
6. Location of microphone.

VAM1500FC

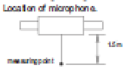


4D082476

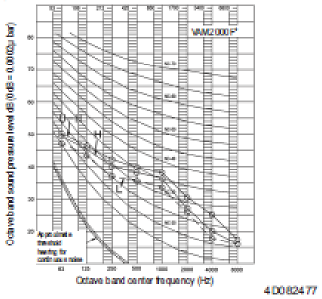
Air flow rate (dB)		
U-H	H	L
39.5	38	34

NOTES

1. Ventilation mode: total heat exchange.
2. Operation noise is measured in an anechoic chamber.
3. The operation noise level may become higher than this value depending on the operation conditions, reflected sound and peripheral noise.
4. Operation noise differs with operation and ambient conditions.
5. U-H: ultra-high, H: high, L: low
6. Location of microphone.



VAM2000FC



4D082477

Air flow rate (dB)		
U-H	H	L
40	38	35

NOTES

1. Ventilation mode: total heat exchange.
2. Operation noise is measured in an anechoic chamber.
3. The operation noise level may become higher than this value depending on the operation conditions, reflected sound and peripheral noise.
4. Operation noise differs with operation and ambient conditions.
5. U-H: ultra-high, H: high, L: low
6. Location of microphone.

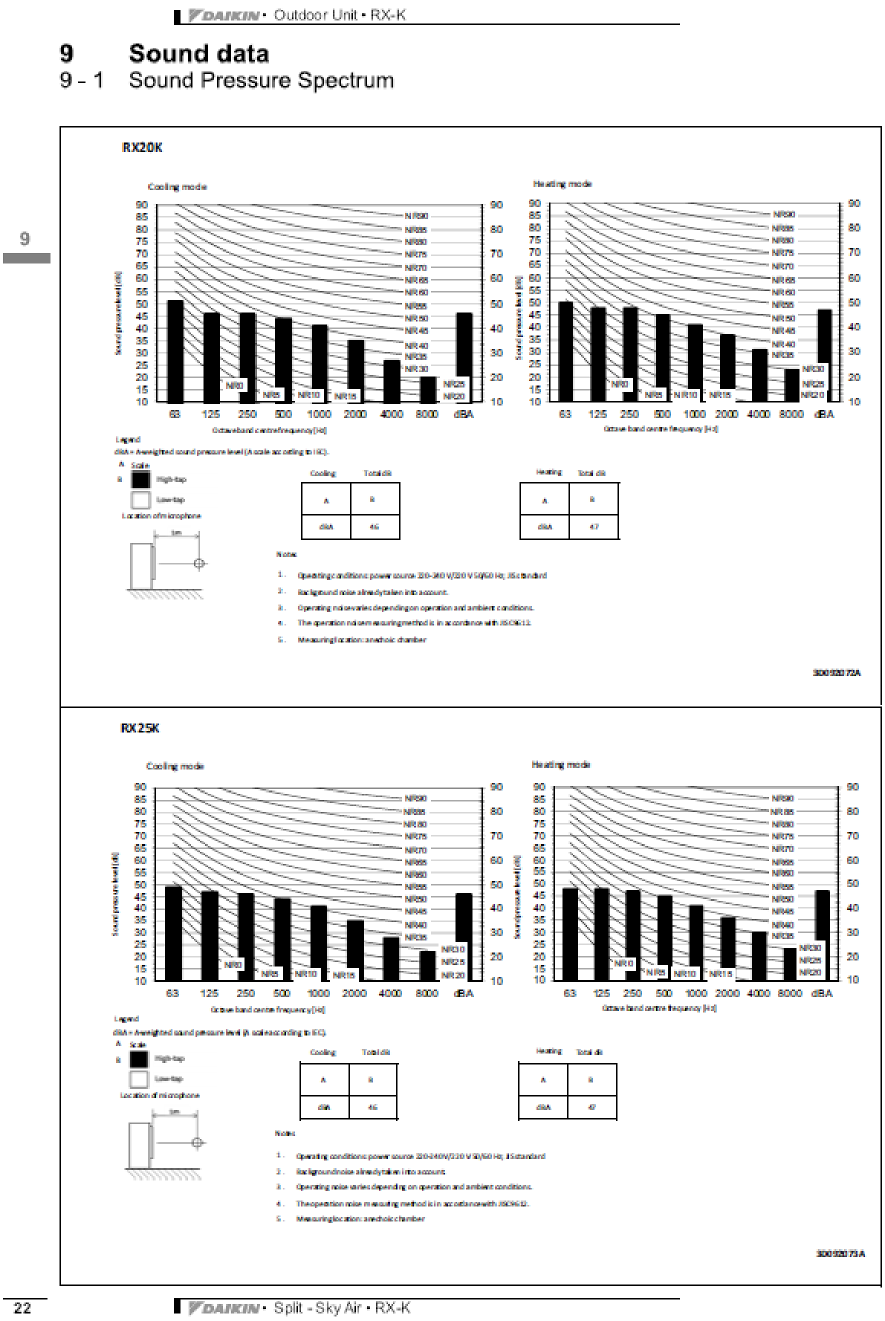
8

[27] Source: Daikin Technical.

Mechanical Equipment

Daikin RX20K[28]

Sound Pressure Spectrum



[28] Source: Daikin Technical.

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APPENDIX 5

Background Noise Measurements

Star Yard (rear)

Hz	dB	dB	dB	dB	dB	dB
Band	**L_{Fmax}**	**L_{Fmin}**	**L_{eq}**	**L_{F10}**	**L_{F50}**	**L_{F90}**
Z	91.2	54.2	63.8	64	59.5	57
C	89.1	51.1	58.5	59	55	53.5
A	72.9	40.8	47.8	49	44	42.5
16	83	42.1	57	57.5	53	49.5
32	83.3	43.5	55.2	56	52	48.5
63	87.3	43.2	54.6	54	49.5	47
125	82.3	42.3	50.3	49.5	47	45
250	74.1	40.4	46.9	48	45.5	43.5
500	70.1	37.8	44.7	46	42.5	40
1k	67.6	34	43.8	45	38.5	36.5
2k	64.5	29.5	39.1	40.5	34.5	31.5
4k	60.8	21.6	34.6	36	28	23
8k	58.5	16.9	30.1	30.5	23	19
16k	58.8	15.2	25.6	23	17	15.5

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Background Noise Measurements

Chancery Lane (front)

Hz	dB	dB	dB	dB	dB	dB
Band	**L_{Fmax}**	**L_{Fmin}**	**L_{eq}**	**L_{F10}**	**L_{F50}**	**L_{F90}**
Z	89.5	55.9	67.7	68.5	61	58.5
C	87.5	53.7	65.9	66	57.5	56
A	84.7	43.8	62.2	61	47.5	45
16	83.6	42.8	58.8	61.5	53.5	49.5
32	86.1	47.1	60.9	61.5	55	52
63	80.2	45	57.5	59	51.5	49
125	81.3	45.6	57.8	59.5	50	48.5
250	80	44.9	56.7	56.5	49	47.5
500	81.3	39.8	56.8	56.5	44.5	42
1k	82.7	37.4	57.9	57	42	39.5
2k	77.4	33.6	54.4	54	39	35.5
4k	83.1	24.9	54.6	46.5	33	27.5
8k	63.5	17.4	38.6	38.5	25	18.5
16k	56.3	15.1	26.9	26.5	17.5	15.5

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APPENDIX 6

Calculation Tables[29]

Front Façade

HE1 Discharge	**Frequency (Hz)**								**Overall**	
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
VAM1000 (UH)	62	59	54	51	49	42	37	28	64	dB(Z)
A-Weighted	36	42	45	47	49	43	38	27	53	dB(A)
Duct (m)	12	12	12	12	12	12	12	12		
Duct Losses per m	0.49	0.66	0.49	0.33	0.23	0.23	0.23	0.23		
Duct Losses	-5.88	-7.92	-5.88	-3.96	-2.76	-2.76	-2.76	-2.76		
Bend 1			-5	-8	-4	-3	-3	-3		
Bend 2[30]			-5	-8	-4	-3	-3	-3		
End Reflection	-11	-7	-3	-1	0	0	0	0		
Corrected SWL	45.1	43.6	35.1	29.5	38.2	33.2	27.7	19.2		
NSR Distance (m)	1	1	1	1	1	1	1	1		
DI	3	3	3	3	3	3	3	3		
Point Source Attenuation	-11	-11	-11	-11	-11	-11	-11	-11		
Directionality	0	0	-4	-6	-9	-14	-17	-19		
Level at Window	37.1	35.6	23.1	15.5	21.2	11.2	2.7	-7.8	40	dB
	10.9	19.5	14.5	12.3	21.2	12.4	3.7	-8.9	25	dB(A)
						No of HE Ducts			2	
						Combined Level @ NSR			**28**	dB(A)

[29] See APPENDIX 2 - Site Location/Plans for mechanical equipment layout.
[30] The attenuation from only 2 bends has been factored (rather than 4) to provide a worst case.

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Noise Calculations

Front Façade

HE2 Discharge	Frequency (Hz)								Overall	
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
VAM1000 (UH)	62	59	54	51	49	42	37	28	64	dB(Z)
A-Weighted	36	42	45	47	49	43	38	27	53	dB(A)
Duct (m)	6	6	6	6	6	6	6	6		
Duct Losses per m	0.49	0.66	0.49	0.33	0.23	0.23	0.23	0.23		
Duct Losses	-2.94	-3.96	-2.94	-1.98	-1.38	-1.38	-1.38	-1.38		
Bend 1			-5	-8	-4	-3	-3	-3		
Bend 2			-5	-8	-4	-3	-3	-3		
End Reflection	-11	-7	-3	-1	0	0	0	0		
Corrected SWL	48.1	47.5	38.1	31.5	39.6	34.6	29.1	20.6		
NSR Distance (m)	1	1	1	1	1	1	1	1		
DI	3	3	3	3	3	3	3	3		
Point Source Attenuation	-11	-11	-11	-11	-11	-11	-11	-11		
Directionality	0	0	-4	-6	-9	-14	-17	-19		
Level at Window	40.1	39.5	26.1	17.5	22.6	12.6	4.1	-6.4	43	dB
	13.9	23.4	17.5	14.3	22.6	13.8	5.1	-7.5	27	dB(A)
						No of HE Ducts			2	
						Combined Level @ NSR			**30**	dB(A)

Noise Calculations

Rear Façade

HE3 Discharge	Frequency (Hz)								Overall	
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
VAM1000 (UH)	62	59	54	51	49	42	37	28	64	dB(Z)
A-Weighted	36	42	45	47	49	43	38	27	53	dB(A)
Duct (m)	1	1	1	1	1	1	1	1		
Duct Losses per m	0.49	0.66	0.49	0.33	0.23	0.23	0.23	0.23		
Duct Losses	-0.49	-0.66	-0.49	-0.33	-0.23	-0.23	-0.23	-0.23		
End Reflection	-11	-7	-3	-1	0	0	0	0		
Corrected SWL	50.5	50.8	50.5	49.2	48.8	41.8	36.3	27.8		
NSR Distance (m)	1	1	1	1	1	1	1	1		
DI	3	3	3	3	3	3	3	3		
Point Source Attenuation	-11	-11	-11	-11	-11	-11	-11	-11		
Directionality	0	0	-4	-6	-9	-14	-17	-19		
Level at Window	42.5	42.8	42.5	41.2	40.8	33.8	28.3	19.8	49	dB
	16.3	26.7	33.9	38.0	40.8	35.0	29.3	18.7	44	dB(A)
						No of HE Ducts			2	
						Combined Level @ NSR			**47**	dB(A)

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Noise Calculations

Rear Façade

HE3 Discharge	**Frequency (Hz)**								**Overall**	
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
VAM1000 (UH)	62	59	54	51	49	42	37	28	64	dB(Z)
A-Weighted	36	42	45	47	49	43	38	27	53	dB(A)
Attenuator 37.5%FA x 600	-4	-6	-10	-18	-25	-23	-22	-17		
Duct (m)	1	1	1	1	1	1	1	1		
Duct Losses per m	0.49	0.66	0.49	0.33	0.23	0.23	0.23	0.23		
Duct Losses	-0.49	-0.66	-0.49	-0.33	-0.23	-0.23	-0.23	-0.23		
End Reflection	-11	-7	-3	-1	0	0	0	0		
Corrected SWL	46.5	44.8	40.5	31.2	23.8	18.8	14.3	10.8		
NSR Distance (m)	1	1	1	1	1	1	1	1		
DI	6	6	6	6	6	6	6	6		
Point Source Attenuation	-11	-11	-11	-11	-11	-11	-11	-11		
Directionality	0	0	-4	-6	-9	-14	-17	-19		
Level at Window	41.5	39.8	31.5	20.2	9.8	-0.2	-7.7	-13.2	44	dB
	15.3	23.7	22.9	17.0	9.8	1.0	-6.7	-14.3	27	dB(A)
						No of HE Ducts			2	
						Combined Level @ NSR			**30**	dB(A)

Noise Calculations

Rear Façade

Condenser Break-Out

	Frequency (Hz)									
Frequency	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**		
SPL	50	48	48	45	41	36	30	24		
SWL	61.0	59.0	59.0	56.0	52.0	47.0	41.0	35.0		
Reverb Increases	0.4	0.4	1.0	2.2	1.0	0.7	0.4	0.4		
SPL_{int}	61.4	59.4	60.0	58.2	53.0	47.7	41.4	35.4		
Partition Wall - SRI COMP	-5	-5	-5	-5	-5	-5	-5	-5		
Break Out (internal-external)	-6	-6	-6	-6	-6	-6	-6	-6		
Surface Area	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5		
$10LOG_S$	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0		
Directivity (reverb path way)	6	6	6	6	6	6	6	6		
Distance (m)	1	1	1	1	1	1	1	1		
Distance Correction	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0		
Directionality	-4.0	-6.0	-9.0	-14.0	-17.0	-19.0	-20.0	-20.0		
Noise Rating	52	48	46	39	31	24	16	10	55	dB
A-Weighted	26	32	37	36	31	25	17	9	**41**	**dB(A)**
Wall	*28*	*34*	*34*	*40*	*56*	*73*	*76*	*78*		
Weather Louvre	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*		
Wall	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*		
Louvre Surface Area (S)	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*		
SRI COMP	*-5*	*-5*	*-5*	*-5*	*-5*	*-5*	*-5*	*-5*		
Surface Area of Partition (S)	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*		

Noise Calculations

Rear Façade

Condenser Break-Out

	Frequency (Hz)									
Frequency	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**		
SPL	50	48	48	45	41	36	30	24		
SWL	61.0	59.0	59.0	56.0	52.0	47.0	41.0	35.0		
Reverb Increases	0.4	0.4	1.0	2.2	1.0	0.7	0.4	0.4		
SPL_{int}	61.4	59.4	60.0	58.2	53.0	47.7	41.4	35.4		
Partition Wall - SRI COMP	-12	-12	-15	-22	-34	-35	-32	-26		
Break Out (internal-external)	-6	-6	-6	-6	-6	-6	-6	-6		
Surface Area	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.5		
$10LOG_S$	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0		
Directivity (reverb path way)	6	6	6	6	6	6	6	6		
Distance (m)	1	1	1	1	1	1	1	1		
Distance Correction	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0	-11.0		
Directionality	-4.0	-6.0	-9.0	-14.0	-17.0	-19.0	-20.0	-20.0		
Noise Rating	46	41	36	22	2	-6	-11	-11	47	dB
A-Weighted	19	25	27	19	2	-5	-10	-12	**30**	**dB(A)**
Wall	*28*	*34*	*34*	*40*	*56*	*73*	*76*	*78*		
Weather Louvre	*7*	*7*	*10*	*17*	*29*	*30*	*27*	*21*		
Wall	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*	*8.5*		
Louvre Surface Area (S)	*4*	*4*	*4*	*4*	*4*	*4*	*4*	*4*		
SRI COMP	*-12*	*-12*	*-15*	*-22*	*-34*	*-35*	*-32*	*-26*		
Surface Area of Partition (S)	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*	*12.5*		

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Noise Calculations

Separating Floor

	Frequency (Hz)								Overall	
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**		
Daikin VAM1000	47	43	39	35	34	27	22	13	49.3	dB
A-Weighted	20.8	26.9	30.4	31.8	34	28.2	23	11.9	38.2	dB(A)
2 Units	3	3	3	3	3	3	3	3		
100mm Concrete Floor	-32	-37	-36	-45	-52	-59	-62	-63		
Attenuated Level	15.0	6.0	3.0	-10.0	-18.0	-32.0	-40.0	-50.0	15.8	dB
A-Weighted	-11.2	-10.1	-5.6	-13.2	-18.0	-30.8	-39.0	-51.1	-2.9	dB(A)

APPENDIX 7

Noise Mitigation Measures

Acoustic Louvre

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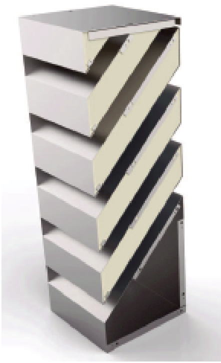
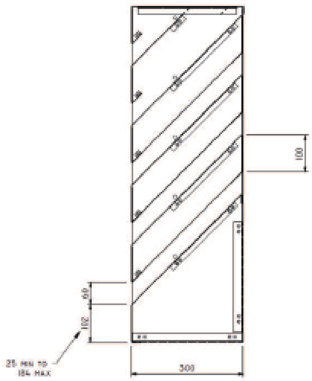
Technical Data For SH300 Acoustic Louvre

Single Bank Acoustic Louvre, Higher Performance Profile, 300mm Deep



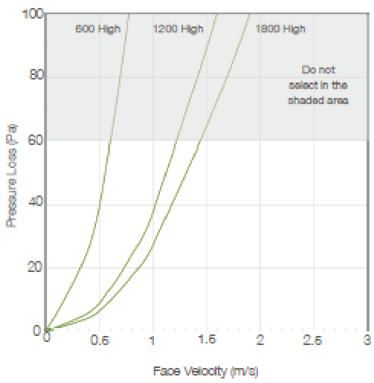
Typical weight 53kg/m²



Performance

Refer to the Performance Data section of this brochure for more details on the following data.

Acoustic Data	dB in each Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Sound reduction Index	7	7	10	17	29	30	27	21
Weighted sound reduction Index (Rw)	21							
Static insertion loss	6	7	10	18	31	28	26	25
Regenerated sound power level at 1m/s face velocity	50	44	39	34	30	26	17	12
Regenerated sound power level at 2m/s face velocity	70	60	55	52	49	49	43	35



Free Area and Height Range		
Height (mm)	Free Area (%)	Airways
665-824	18-15	2
825-984	22-18	3
985-1144	24-21	4
1145-1304	26-23	5
1305-1464	28-25	6
1465-1624	29-26	7
1625-1784	30-27	8
1785-1944	30-28	9
1945-2104	31-29	10
2105-2264	31-29	11
2265-2400	32-30	12

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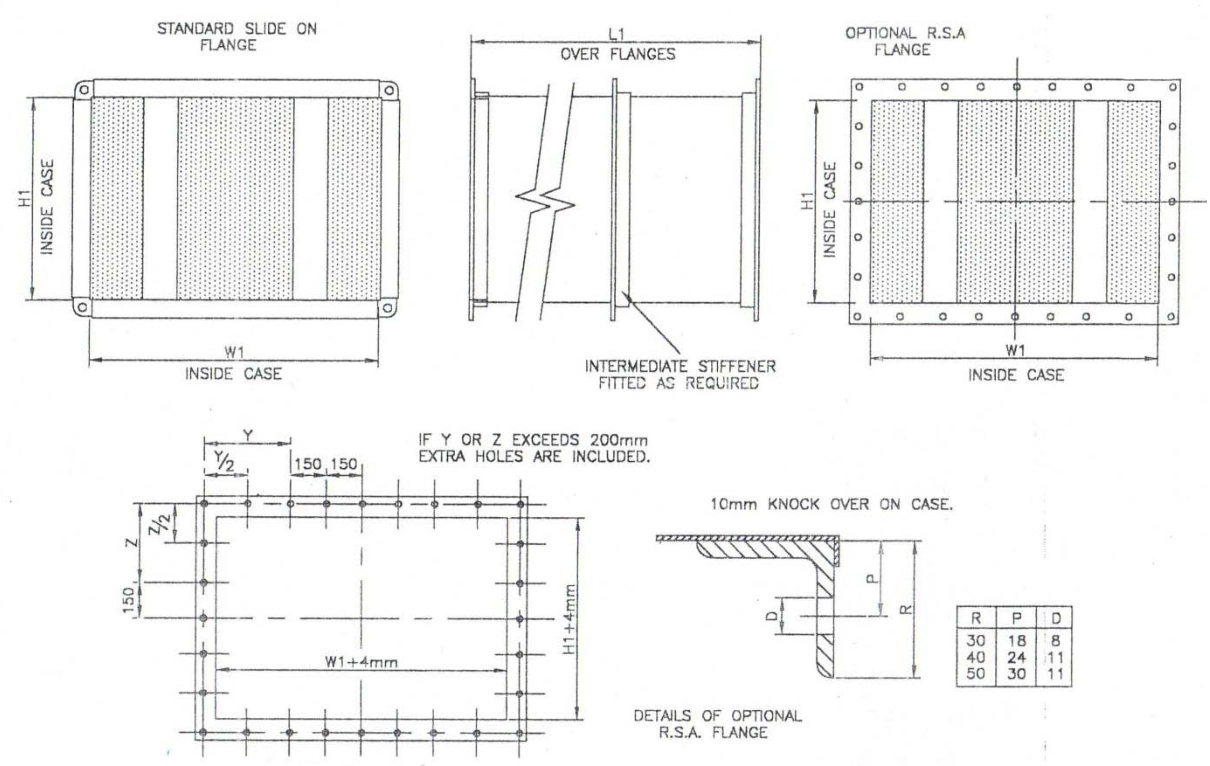
Noise Mitigation Measures

Rectangular Attenuators

Cross-Section



OPTIONS:

Attenuator end connections:

- Rolled steel angle flanges (rectangular).
- Slide on Doby type flanges (rectangular).
- Spigot ends (both).
- End flanges that incorporate threaded inserts (circular).

Splitter orientation:

- Vertically mounted splitters (rectangular).
- Horizontally mounted splitters (rectangular).

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Noise Mitigation Measures

Rectangular Attenuators

Insertion Losses

37.5% FA, 120mm Airway, C=4.56								
Length	63	125	250	500	1K	2K	4K	8K
450	4	5	8	14	22	20	19	16
600	4	6	10	18	25	23	22	17
750	4	7	12	21	28	26	24	19
900	4	8	14	24	31	29	26	20
1200	5	10	18	30	38	35	31	23
1500	5	12	23	36	44	41	36	26
1800	5	14	27	42	45	45	40	29
2100	6	16	31	45	45	45	45	32
2400	6	18	35	45	45	45	45	35

40% FA, 133mm Airway, C=5.06								
Length	63	125	250	500	1K	2K	4K	8K
450	4	4	7	14	21	18	18	15
600	4	5	9	17	24	21	20	16
750	4	6	11	20	27	24	23	17
900	4	7	13	22	30	27	25	18
1200	5	9	17	28	37	34	29	20
1500	5	11	21	34	43	40	33	22
1800	5	13	25	40	45	45	38	24
2100	5	15	29	45	45	45	42	26
2400	5	17	33	45	45	45	45	28

42.5% FA, 148mm Airway, C=5.61								
Length	63	125	250	500	1K	2K	4K	8K
450	4	4	7	13	19	18	17	14
600	4	5	8	16	22	21	18	15
750	4	6	10	18	25	24	20	16
900	4	7	12	21	28	27	22	16
1200	4	8	16	27	35	32	26	18
1500	5	10	19	33	41	38	29	20
1800	5	12	23	38	45	44	33	21
2100	5	14	27	44	45	45	36	23
2400	5	16	30	45	45	45	40	24

45% FA, 164mm Airway, C=6.21								
Length	63	125	250	500	1K	2K	4K	8K
450	3	4	6	13	18	17	16	13
600	4	5	8	15	21	20	17	14
750	4	5	10	18	24	23	19	15
900	4	6	11	21	28	25	21	16
1200	4	8	15	26	34	31	24	17
1500	4	10	19	32	40	36	27	19
1800	5	11	22	37	45	41	31	20
2100	5	13	26	42	45	45	34	22
2400	5	15	29	45	45	45	37	23

47.5% FA, 181mm Airway, C=6.87								
Length	63	125	250	500	1K	2K	4K	8K
450	3	3	5	12	16	15	14	12
600	4	4	7	14	19	17	15	13
750	4	5	8	17	23	20	17	14
900	4	5	10	20	26	22	18	14
1200	4	7	14	25	32	27	21	16
1500	4	8	17	30	38	32	23	17
1800	4	10	21	35	44	38	26	18
2100	4	11	24	40	45	43	28	19
2400	4	13	27	45	45	45	31	20

50% FA, 200mm Airway, C=7.6								
Length	63	125	250	500	1K	2K	4K	8K
450	3	3	4	12	14	13	12	12
600	3	4	6	14	18	15	13	12
750	3	4	7	17	21	18	14	13
900	3	5	9	19	24	20	15	13
1200	4	6	12	24	30	25	17	14
1500	4	7	15	29	37	29	20	15
1800	4	9	18	34	43	34	22	16
2100	4	10	21	38	45	39	24	17
2400	4	11	24	43	45	43	26	18

52.5% FA, 221mm Airway, C=8.39								
Length	63	125	250	500	1K	2K	4K	8K
450	3	3	4	11	13	12	11	11
600	3	4	5	13	16	14	12	11
750	3	4	7	16	19	16	13	12
900	3	5	8	18	22	18	14	12
1200	4	6	11	22	28	22	16	13
1500	4	7	14	27	34	27	18	14
1800	4	8	17	32	40	31	20	15
2100	4	9	20	36	45	35	22	16
2400	4	10	23	41	45	39	24	17

55% FA, 244mm Airway, C=9.28								
Length	63	125	250	500	1K	2K	4K	8K
450	3	3	4	10	12	11	11	10
600	3	4	5	12	14	13	11	10
750	3	4	7	15	17	15	12	11
900	3	5	8	17	20	17	13	11
1200	3	6	11	21	25	21	15	13
1500	4	7	14	25	31	25	17	14
1800	4	8	17	29	36	29	19	15
2100	4	9	20	34	42	33	20	16
2400	4	10	23	38	45	37	22	17

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APPENDIX 8

CIBSE NR Tables

CIBSE RECOMMENDED NOISE RATINGS FOR INTERNAL AREAS

Situation	NR Value
Concert halls, opera halls, studios for sound reproduction, live theatres (>500 seats).	20
Bedrooms in private homes, live theatres (<500 seats), cathedrals and large churches, television studios, large conference and lecture rooms (>50 people).	25
Living rooms in private homes, board rooms, top management offices, conference and lecture rooms (20-50 people), multi-purpose halls, churches (medium and small), libraries, bedrooms in hotels, etc., banqueting rooms, operating theatres, cinemas, hospital private rooms, large courtrooms.	30
Public rooms in hotels, etc., ballrooms, hospital open wards, middle management and small offices, small conference and lecture rooms (<20 people), school classrooms, small courtrooms, museums, libraries, banking halls, small restaurants, cocktail bars, quality shops.	35
Toilets and washrooms, drawing offices, reception areas (offices), halls, corridors, lobbies in hotels, etc., laboratories, recreation rooms, post offices, large restaurants, bars and night clubs, department stores, shops, gymnasia.	40
Kitchens in hotels, hospitals, etc., laundry rooms, computer rooms, accounting machine rooms, cafeteria, canteens, supermarkets, swimming pools, covered garages in hotels, offices, etc., bowling alleys, landscaped offices.	45

<u>NR50 and above:</u>

NR50 will generally be regarded as very noisy by sedentary workers but most of the classifications listed under NR45 could just accept NR50. Higher noise levels than NR50 will be justified in certain manufacturing areas; such cases must be judged on their own merits.

<u>Notes:</u>

1. The ratings listed above will give general guidance for total services noise but limited adjustment of certain of these criteria may be appropriate in some applications.
2. The intrusion of high external noise levels may, if continuous during occupation, permit relaxation of the standards but services noise should be not less than 5 dB below the minimum intruding noise in any octave band to avoid adding a significant new noise source to the area.
3. Where more than one noise source is present it is the aggregate noise which should meet the criterion.
4. NR is approximately equal to dB(A) value - 6.

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CIBSE NR Tables

TABLE 11 - DESIGN CRITERIA

	31.5	63	125	250	500	1000	2000	4000	8000	dB(A)
NR100	123	115	109	105	102	100	98	96	95	106
NR95	120	111	105	100	97	95	93	91	90	101
NR90	117	107	100	96	92	90	88	86	85	96
NR85	113	103	96	91	87	85	83	81	80	92
NR80	110	99	91	86	82	80	78	76	74	87
NR75	106	95	87	82	78	75	73	71	69	82
NR70	103	91	83	77	73	70	68	66	64	77
NR65	100	87	78	72	68	65	62	61	59	72
NR60	96	83	74	68	63	60	57	55	54	67
NR55	93	79	70	63	58	55	52	50	49	62
NR50	89	75	65	59	53	50	47	45	43	58
NR45	86	71	61	54	48	45	42	40	38	53
NR40	83	67	57	49	44	40	37	35	33	48
NR35	79	63	52	45	39	35	32	30	28	44
NR30	76	59	48	40	34	30	27	25	23	39
NR25	72	55	44	35	29	25	22	20	18	35
NR20	69	51	39	31	24	20	17	14	13	30
NR15	66	47	35	26	19	15	12	9	7	25
NR10	62	43	31	21	15	10	7	4	2	21