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Consultants in Acoustics, Noise & Vibration

16297-R01-C

17 April 2018

Bedford House

Planning noise report

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Version	Date	Comments	Author	Reviewer
A	03 Aug 16		David Elliott	Daniel Stringer
B	31 Jul 17	Plant assessment	David Elliott	Daniel Stringer
C	17 Apr 18	Camden criteria and plant assessment updated	David Elliott	Robert Burrell

Summary

Sandy Brown (SB) has been commissioned by 6A architects on behalf of Holborn Community Agency to provide acoustic advice in relation to noise emission from building services plant associated with the proposed development at Bedford House which is located at 35 Emerald Street, London.

An environmental noise survey was performed between 20 July 2016 and 26 July 2016. The representative background sound levels measured during the survey were $L_{A90,15min}$ 44 dB during the daytime and $L_{A90,15min}$ 42 dB at night.

Based on the requirements of the Camden Council and on the results of the noise survey, all plant must be designed such that the cumulative noise level at 1 m from the worst affected windows of the nearby noise sensitive premises does not exceed L_{Aeq} 34 dB during the daytime and L_{Aeq} 32 dB during the night.

An assessment of the building services plant associated with the development has been carried out and noise emissions are expected to comply with Camden Council requirements.

Contents

1 Introduction

Sandy Brown (SB) has been commissioned by 6A architects on behalf of Holborn Community Agency to provide acoustic advice in relation to the proposed development at Bedford House which is located at 35 Emerald Street, London.

An environmental noise survey has been carried out, the purpose of which was to establish the existing ambient and background sound levels in the vicinity of the site and nearby noise sensitive premises.

The background sound levels measured during the survey are used as the basis for setting limits for noise emission from proposed building services plant. These limits are set in accordance with the requirements of the Camden Council.

This report presents the noise survey methods, the results of the survey, a discussion of acceptable limits for noise emissions from building services plant. An assessment of noise levels from proposed items of plant has been undertaken and is also summarised in this report.

2 Site description

2.1 The site and its surroundings

The site location in relation to its surroundings is shown in Figure 1. It is located on Emerald Street, a small side street which runs off Lamb’s Conduit Street located in the Bloomsbury area of Camden.

Figure 1 Site map (courtesy of Google Earth Pro) showing measurement position, L site (red), adjacent commercial buildings (blue) and adjacent mixed use buildings (green) which include residential premises.

2.2 Adjacent premises

The site is surrounded by buildings of both commercial and residential use. It is located between 23-29 Emerald Street and Rapier House, two office buildings which are shown in blue in Figure 1. The site backs onto the rear of the residential buildings located on Lamb’s Conduit Street and Emerald Street and also sits opposite the residential townhouses on Rugby Street. These are shown in green in Figure 1.

3 Method

Details of the equipment used, the noise indices and the weather conditions during the survey are provided in Appendix A. Further information on the specific survey method is provided in this section.

3.1 Unattended measurements

Unattended noise monitoring was undertaken at the site over 6 days to determine the existing background sound levels in the vicinity of nearby noise sensitive premises.

The unattended measurements were performed over 15 minute periods between 15:00 on 20 July 2016 and 15:00 on 26 July 2016. The equipment was installed and collected by Eric Ballestero.

The measurement position used during the survey is indicated in Figure 1, denoted by the letter 'L'. A photograph showing the measurement location is provided in Figure 2. This location was chosen to be representative of the noise levels experienced by the nearest noise sensitive premises.

The microphone was located in the free-field.

Figure 2 Photograph showing unattended monitor a location L

4 Measurement results

4.1 Observations

The dominant noise sources observed at the site during the survey consisted of road traffic from the surrounding area and aircraft passes.

Less significant noise sources included pedestrians and residents of the surrounding buildings.

Between 13:00 and 14:00 on 22 July 2016 noise levels much higher than typical were measured. It is expected that this was due to an alarm or helicopter and this measurement period has been discounted from the analysis.

On 25 July 2016 and 26 July 2016 the measured background noise level is dominated by a constant noise source from 09:00 to 17:00, expected to be construction works. This does not affect the analysis undertaken to assess the typical background noise level.

4.2 Unattended measurement results

The results of the unattended noise measurements are summarised in the following tables. A graph showing the results of the unattended measurements is provided in Appendix B.

The day and night time ambient noise levels measured during the unattended survey are presented in Table 1.

Table 1 Ambient noise levels measured during the survey

Date	Daytime (07:00 – 23:00) $L_{\text{Aeq,16h}}$ (dB)	Night (23:00 – 07:00) $L_{\text{Aeq,8h}}$ (dB)
Wednesday 20 July 2016	n/a	47
Thursday 21 July 2016	50	47
Friday 22 July 2016	49*(excluded loud period)	49
Saturday 23 July 2016	48	46
Sunday 24 July 2016	50	44
Monday 25 July 2016	50	47
Average	49	47

In line with BS 4142:2014, for the purpose of analysis and establishing representative background sound levels, day and night time typical levels have been quantified using statistical analysis from the continuous logging measurements.

Daytime and night time statistical analysis of representative values for the site are given in Figure 3 and Figure 4.

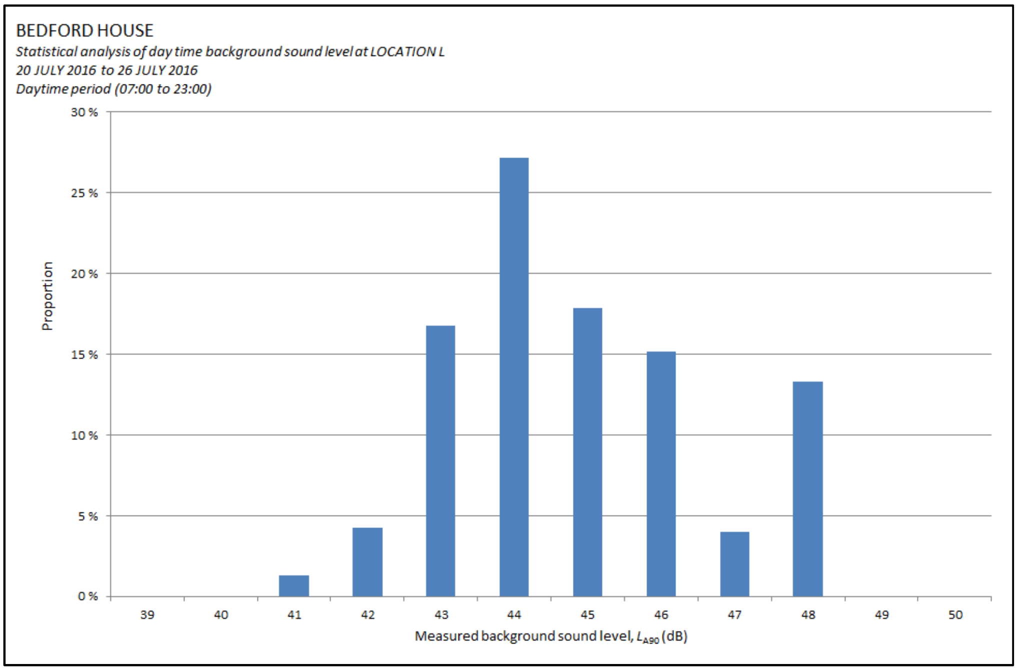


Figure 3 Graph showing statistical analysis of daytime background noise level (07:00 - 23:00)

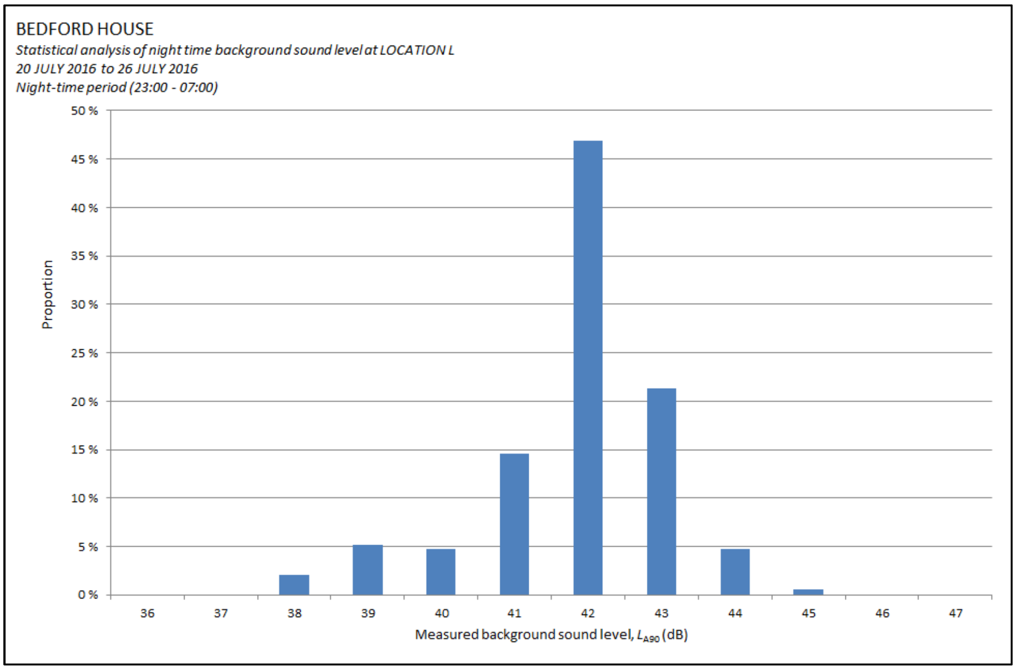


Figure 4 Graph showing statistical analysis of night time background noise level (23:00 - 07:00)

From this analysis, the representative background sound levels measured during the survey were $L_{A90,15min}$ 44 dB during the daytime and $L_{A90,15min}$ 42 dB at night.

5 Assessment criteria – building services noise egress limits

5.1 Standard guidance

Guidance for noise emission from proposed new items of building services plant is given in BS 4142: 2014 '*Methods for rating and assessing industrial and commercial sound*'.

BS 4142 provides a method for assessing noise from items such as building services plant against the existing background sound levels at the nearest noise sensitive premises.

BS 4142 suggests that if the noise level is 10 dB or more higher than the existing background sound level, it is likely to be an indication of a significant adverse impact. If the level is 5 dB above the existing background sound level, it is likely to be an indication of an adverse impact. If the level does not exceed the background level, it is an indication of having a low impact.

If the noise contains 'attention catching features' such as tones, bangs etc, a penalty, based on the type and impact of those features, is applied.

5.2 Local Authority criteria

Camden's latest Local Plan (2017) states that any building services plant shall not exceed a noise 'rating' level of 10 dB less than the existing background noise level. It is also states that 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 ($L_{90,\ 15min}$).

5.3 Plant noise limits

Based on the Camden Council requirements and the measurement results, the cumulative noise level resulting from the operation of all new plant at 1 m from the worst affected windows of the nearest noise sensitive premises should not exceed the limits set out in Table 2.

Table 2 Plant noise limits at 1 m from the nearest noise sensitive premises

Time of day	Maximum sound pressure level at 1 m from noise sensitive premises ($L_{Aeq,15min}$ dB)
Daytime (07:00-23:00)	34
Night-time (23:00-07:00)	32

6 Plant noise assessment

6.1 Proposed installation

The following sections detail the proposed installation of building services plant.

A ventilation schematic showing the location of all units is provided in Appendix C.

All units will run during daytime hours (07:00-23:00).

6.1.1 External units

There will be a number of units housed on the roof of the development, listed below:

- Flaktwoods eQ Prime air handling unit serving basement gym (AHU1) shown in blue in Figure 5
- Trane CGA air/water chiller shown in orange in Figure 5
- Flaktwoods Gleb kitchen extract fan (EF2.1) shown in blue in Figure 6.

6.1.2 Internal units

There are also internal mechanical ventilation units and fans which have atmosphere-side intake and exhausts located on the roof of the development. These are as follows:

- Flaktwoods Eco Premium Elite air handling unit serving basement studio (AHU2) with intake and discharge shown in green in Figure 5
- 2 no. Zehnder ComfoAir Q MVHR/air handling units (AHU3, AHU4) with intake and discharge shown in green and purple on Figure 6
- Nuaire Dave kitchen supply fan (SFB.1) with intake shown in green on Figure 6
- Nuaire ES-OPUS WC extract fan (EF0.1). with discharge shown in purple on Figure 6.

6.2 Noise sensitive receptors

There are a number of residential windows to the south of the development, as shown in green in Figure 1. The nearest receptor is a kitchen window located around 3.6 m from the south edge of the development's rooftop as detailed in Figure 5.

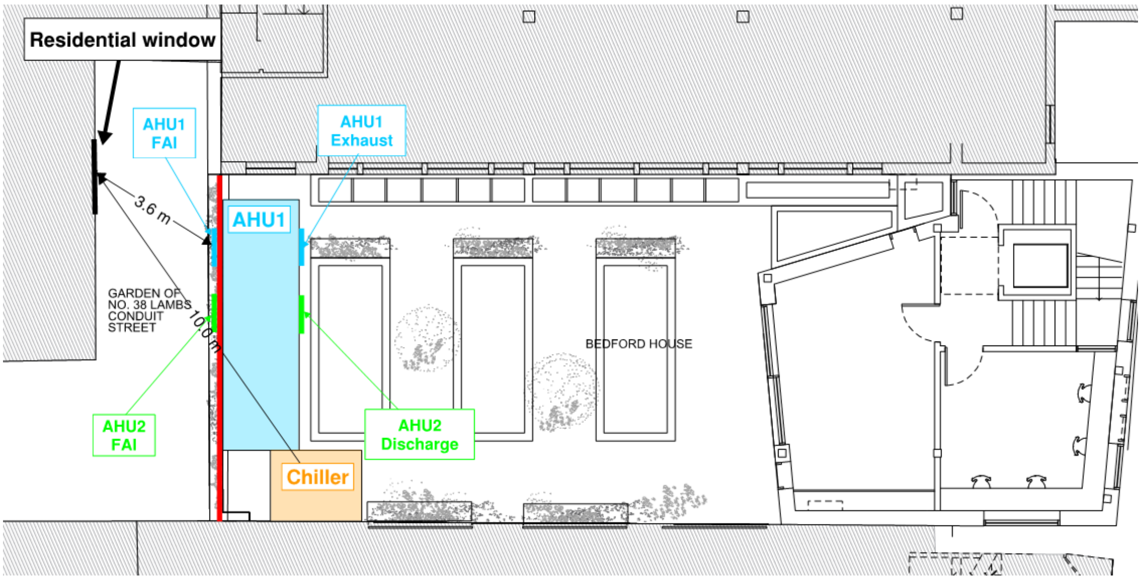


Figure 5 Roof plan showing plant items and nearest residential window

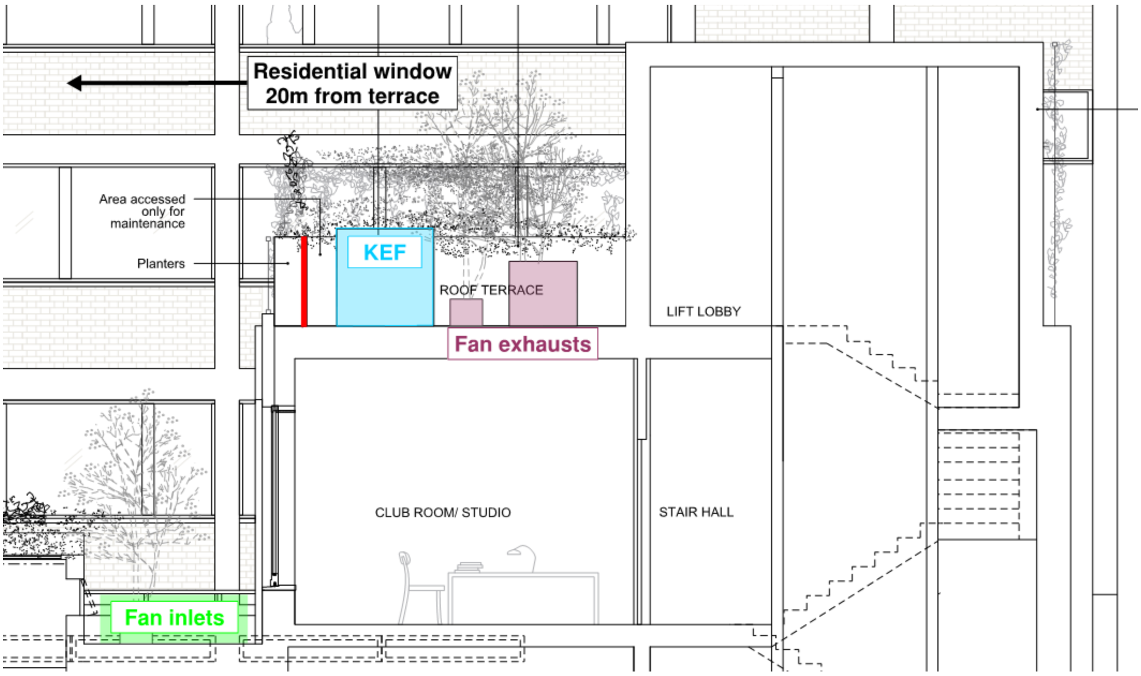


Figure 6 Section showing plant items

6.3 Mitigation measures

6.3.1 Acoustic enclosures

The air handling unit and chiller unit will be housed in acoustic enclosures manufacturer by Noico which achieve the octave band insertion losses shown in Table 3.

Table 3 Octave band insertions losses for acoustic enclosure (dB)

	Octave-band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Insertion loss	5	8	14	27	38	40	33	31

6.3.2 Ductwork attenuators

Ductwork attenuators will be fitted to the atmosphere side connections of a AHU1, AHU2 and the kitchen extract fan (EF2.1). The specified octave band insertion losses for the various attenuators are shown in Table 4.

Table 4 Octave band insertion losses for ductwork attenuators (dB)

	Octave-band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
AHU1 Intake	4	11	27	34	34	25	20	17
AHU1 Exhaust	4	11	27	34	34	25	20	17
AHU2 Intake	6	6	10	19	30	27	16	14
AHU2 Exhaust	8	8	13	23	34	30	17	14
Kitchen Extract discharge	n/a	10	18	29	21	17	15	13

In addition to the above, the AHU1 housing will include a lined bend (25 mm melamine lining or similar) on the fresh air intake side to provide the octave band insertion losses shown in Table 5.

Table 5 Octave band insertions losses for ductwork bend with 25 mm lining (dB)

	Octave-band centre frequency (Hz)							
	63	125	250	500	1000	2000	4000	8000
Insertion loss	0	0	1	4	7	7	7	7

6.4 Assessment

The daytime octave band cumulative sound pressure levels at 1 m from the nearest noise sensitive receptor have been calculated and are shown in Table 6. Full calculation stages are shown in Appendix D.

Table 6 Calculated cumulative octave band sound pressure level at 1 m from nearest noise sensitive receptor (dB)

	Octave-band centre frequency (Hz)								A-weighted SPL (dB)
	63	125	250	500	1k	2k	4k	8k	
AHU01 Case radiated	21	27	26	1	-17	-12	-4	-13	19
AHU01 FAI	26	31	33	24	16	21	25	23	31
AHU01 Exhaust	29	25	21	14	11	17	17	18	24
AHU03 FAI	31	28	26	4	0	0	-2	-3	19
AHU03 Exhaust	12	12	9	-7	-28	-30	-25	-30	2
AHU04 FAI	22	22	23	-5	-13	-2	0	-2	16
AHU04 Exhaust	3	3	1	-10	-29	-31	-26	-31	-5
SFB.1 FAI	4	24	19	14	0	5	3	1	16
EF2.1 Exhaust	32	19	14	-10	-14	-11	-19	-28	10
EF2.1 Case radiated	22	15	20	9	10	1	-3	-9	15
EF0.1 Exhaust	-57	12	3	-2	-8	-13	-23	-34	1
Chiller	46	39	28	11	-3	-8	-7	-11	25
Cumulative level	46	39	28	11	-3	-8	-7	-11	33

The level at the nearest receptor is dominated by the fresh air intake of AHU 1. This inlet has been specifically designed with an integrated ductwork attenuator and an acoustically lined bend at the intake. These attenuation measures will mitigate both the fan noise and airflow-generated noise to ensure that the cumulative plant noise limit will be met.

The results of the assessment demonstrate that the daytime plant noise limit specified in Table 2 will be satisfied. Plant will not run during night time hours.

7 Conclusion

The measured representative background sound levels were $L_{A90,15min}$ 44 dB during the day, and $L_{A90,15min}$ 42 dB during the night. On the basis of the requirements of the Local Authority, the relevant plant noise limits at the worst affected existing noise sensitive premises would be L_{Aeq} 34 dB during the day, and L_{Aeq} 32 dB during the night. These limits are cumulative, and apply with all plant operating under normal conditions. If plant items contain tonal or attention catching features, the limits will be more stringent than those set out above.

An assessment of the building services plant associated with the development has been carried out and noise emissions are expected to comply with Camden Council requirements.

Appendix A - Survey details

Equipment

A Rion NL-32 sound level meter was used to undertake the unattended measurements. The calibration details for the equipment used during the survey are provided in Table A1.

Table A1 Equipment calibration data

Equipment description	Type/serial number	Manufacturer	Calibration expiry	Calibration certification number
NL-32A				
Sound level meter	NL-32/00623769	Rion	05 Oct 17	1510538
Microphone	UC-53A/319244	Rion	05 Oct 17	1510538
Pre-amp	NH-21/36677	Rion	05 Oct 17	1510538
Calibrator	NC-74/34336009	Rion	02 Oct 17	1510531

Calibration of the sound level meters used for the tests is traceable to national standards. The calibration certificates for the sound level meter used in this survey are available upon request.

The sound level meters and microphones were calibrated at the beginning and end of the measurements using their respective sound level calibrators. No significant deviation in calibration occurred.

Noise indices

The equipment was set to record a continuous series of broadband sound pressure levels. Noise indices recorded included the following:

- $L_{\mathrm{Aeq},T}$ The A-weighted equivalent continuous sound pressure level over a period of time, T.
- $L_{\mathrm{AFmax},T}$ The A-weighted maximum sound pressure level that occurred during a given period with a fast time weighting.
- $L_{\mathrm{A90},T}$ The A-weighted sound pressure level exceeded for 90% of the measurement period. Indicative of the background sound level.

The L_{A90} is considered most representative of the background sound level for the purposes of complying with any local authority requirements.

Sound pressure level measurements are normally taken with an A-weighting (denoted by a subscript 'A', eg L_{A90}) to approximate the frequency response of the human ear.

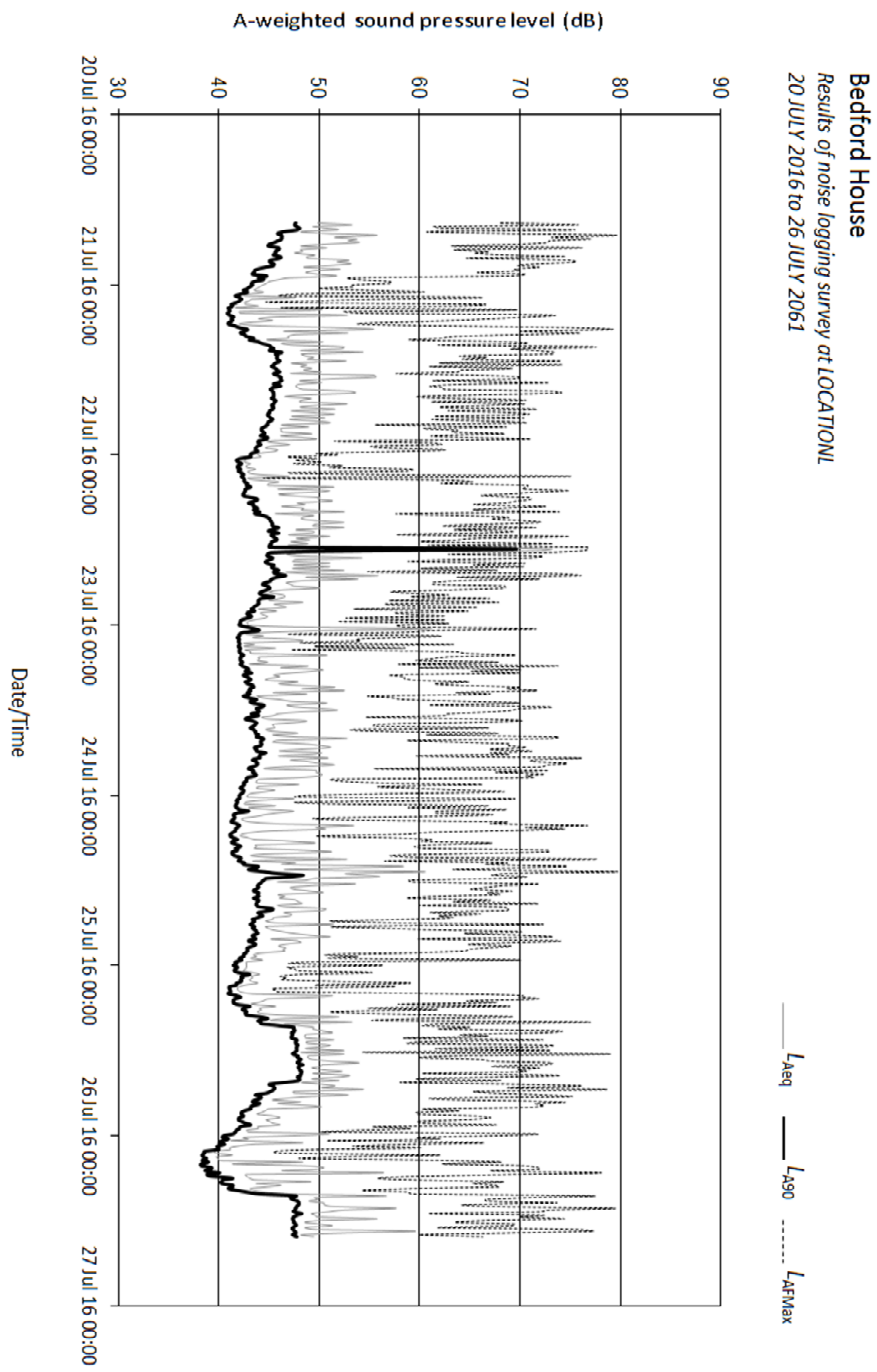
A more detailed explanation of these quantities can be found in BS7445: Part 1: 2003 *Description and measurement of environmental noise, Part 1. Guide to quantities and procedures.*

Weather conditions

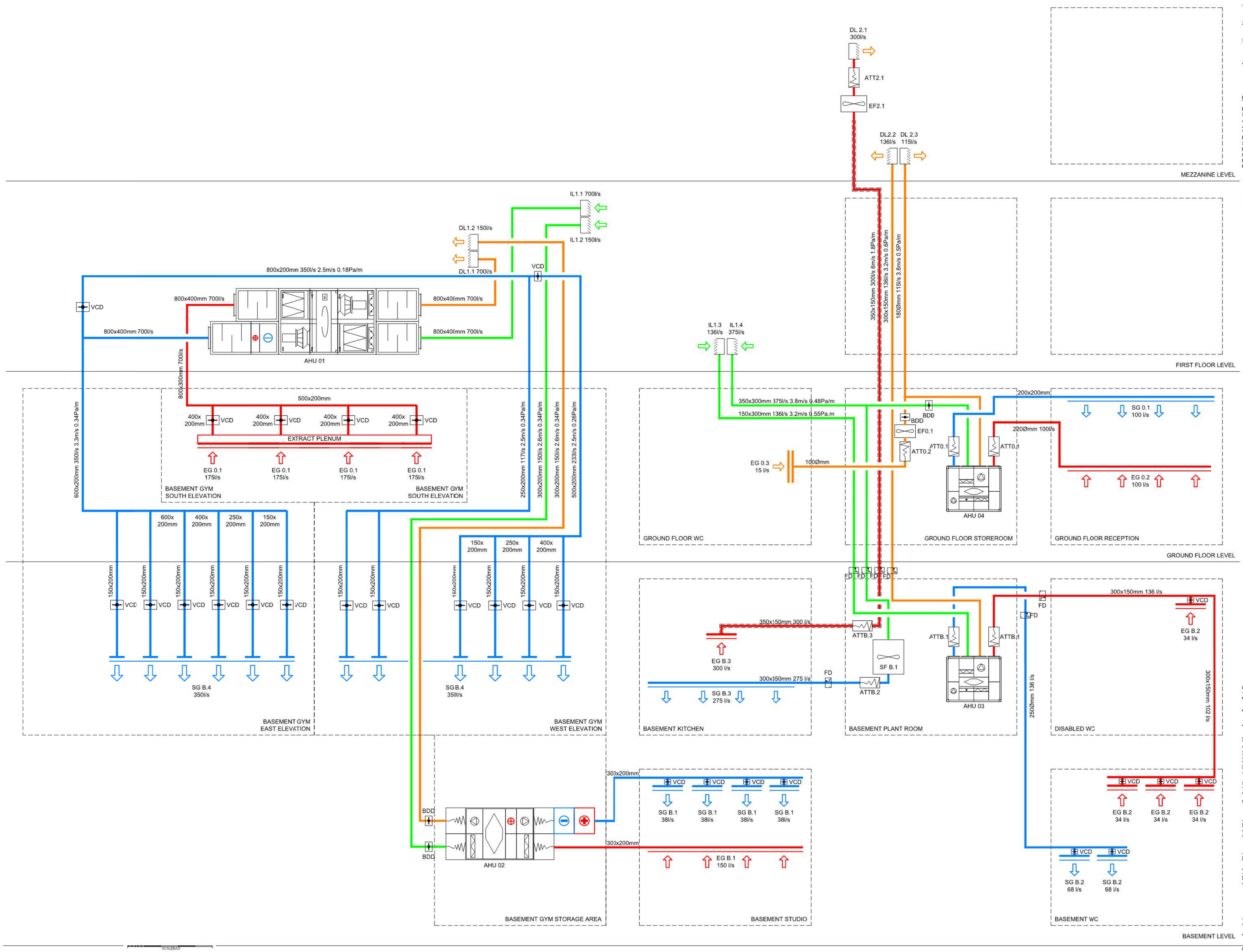
During the unattended noise measurements between 20 July 2016 and 26 July 2016, weather reports for the area indicated that temperatures varied between 16°C at night and 27°C during the day, and the wind speed was generally less than 4 m/s.

These weather conditions are considered suitable for obtaining representative measurements.

Appendix B - Results of unattended measurements at Location L


Bedford House
Results of noise logging survey at LOCATIONL
20 JULY 2016 to 26 JULY 2061
A-weighted sound pressure level (dB)
30
40
50
60
70
80
90
20 Jul 16 00:00
21 Jul 16 00:00
22 Jul 16 00:00
23 Jul 16 00:00
24 Jul 16 00:00
25 Jul 16 00:00
26 Jul 16 00:00
27 Jul 16 00:00
Date/Time
L_Aeq
L_A90
L_AFMax

Appendix C – Ventilation schematic



NOTES

1. THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL R+D SPECIFICATIONS & SCHEDULES
2. ALL DUCTWORK TO BE METAL GALVANIZED, NO FLEXIBLE DUCTWORK
3. REFER TO ARCHITECTS DRAWINGS FOR ALL SETTING OUT DETAILS AND DIMENSIONS OF ALL VISIBLE EQUIPMENT
4. SUPPLY AND EXTRACT GRILLES SHALL BE DESIGNED BY THE ARCHITECT TO ACHIEVE THE REQUIRED FREE AREAS. THESE ARE EXPECTED TO BE CNC CUT SURFACES OR CONCEALED SLOTS RATHER THAN PROPRIETARY GRILLES

KEY

EF - EXTRACT FAN
SF - SUPPLY FAN
AHL - AIR HANDLING UNIT
ATT - ATTENUATOR
VCC - VELOCITY CONTROL DAMPER
BDC - BACK-DRAFT DAMPER
SG - SUPPLY GRILLE
EG - EXTRACT GRILLE
IL - INTAKE LOUVRE
DL - DISCHARGE LOUVRE
FD - FIRE DAMPER

- FIRE RATED AIR EXTRACT DUCT
- AIR EXTRACT DUCT
- AIR SUPPLY DUCT
- AIR INTAKE DUCT
- AIR DISCHARGE DUCT

rev	date	description
T1	23.06.17	ISSUE FOR TENDER
*	15.05.17	STAGE 4F ISSUE FOR COSTING

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Architect
6c Architects

Project Title
Bedford House

Date: Aug '16
Scale (at A4): NTS

Drawing Title
Ventilation Schematic

Job no: J015
Dwg no: U[20] 020
Rev: / T1

Appendix D – Plant noise assessment calculations

Comments	63	125	250	500	1k	2k	4k	8k	Rating 1	Rating 2
			Octave band centre frequency (Hz)							
DE Bedford House plant noise assessment										
17/04/2018				Nearest noise sensitive receptor criteria:					D34	N32
Unit sound power data (Lw, dB) and attenuator insertion loss (IL, dB)										
AHU01 - location L1 rooftop										
Lw, Fresh air intake	50	51	51	45	39	44	48	46	L_A= 53	
Lw, Exhaust	63	56	52	49	50	57	60	64	L_A= 66	
Lw, To surroundings	48	57	62	50	43	50	51	40	L_A= 58	
AHU2 - location Basement										
Lw, Intake	61	53	52	33	33	33	33	33	L_A= 46	
Lw, Exhaust	64	59	58	48	33	33	41	39	L_A= 52	
AHU03 (assumed spectrum)										
Lw, Supply	83	75	74	55	55	55	55	55	L_A= 68	
Lw, Extract	67	62	61	51	36	36	44	42	L_A= 55	
AHU04 (assumed spectrum)										
Lw, Supply	74	66	65	46	46	46	46	46	L_A= 59	
Lw, Extract	60	55	54	44	29	29	37	35	L_A= 48	
SFB1 - location basement plant room										
Lw, Inlet	75	70	61	61	52	51	49	47	L_A= 62	
EF2.1 - location rooftop										
Outlet SWL	84	77	79	70	63	61	53	45	L_A= 73	
Surroundings SWL	59	53	60	51	55	49	48	45	L_A= 58	
IL, Attenuator (2.1)		10	18	29	21	17	15	13		
EF0.1 - location GF storeroom										
Outlet		64	56	53	52	49	42	34	L_A= 57	
Trane chiller - location L1 rooftop										
Sound power	82	78	73	69	67	64	58	53	L_A= 72	
Noico enclosures										
Enclosure insertion loss	5	8	14	27	38	40	33	31		
Duct losses (inc silencers) - Calculations based on CIBSE and ASHRAE guidance on duct noise attenuation										
AHU01										
Intake										
400mm Rec Elbow w/TV+25Lin	0	0	-1	-4	-7	-7	-7	-7		
End Ref.Loss 0.3m2 (d=0.62)	-8	-4	-1	0	0	0	0	0		
SUM	**-8**	**-4**	**-2**	**-4**	**-7**	**-7**	**-7**	**-7**		
Discharge										
400mm Rec UL Elbow w/TV	0	0	-1	-4	-6	-4	-4	-4		
End Ref.Loss 0.3m2 (d=0.62)	-8	-4	-1	0	0	0	0	0		
SUM	**-8**	**-4**	**-2**	**-4**	**-6**	**-4**	**-4**	**-4**		
AHU02										
Intake										
200x300mm Rec UL Duct	-1	-1	0	0	0	0	0	0		
10m	-11	-6	-3	-2	-2	-2	-2	-2		
300mm Rec UL No TV Elbow	0	0	-1	-5	-8	-4	-3	-3		
4 bends	0	0	-4	-20	-32	-16	-12	-12		
End Ref.Loss 0.06m2 (d=0.28)	-13	-8	-4	-2	-1	0	0	0		
SUM	**-26**	**-15**	**-12**	**-29**	**-43**	**-22**	**-17**	**-17**		
Discharge										
200x300mm Rec UL Duct	-1	-1	0	0	0	0	0	0		
10m	-11	-6	-3	-2	-2	-2	-2	-2		
300mm Rec UL No TV Elbow	0	0	-1	-5	-8	-4	-3	-3		
4 bends	0	0	-4	-20	-32	-16	-12	-12		
End Ref.Loss 0.06m2 (d=0.28)	-13	-8	-4	-2	-1	0	0	0		
SUM	**-26**	**-15**	**-12**	**-29**	**-43**	**-22**	**-17**	**-17**		
AHU03										
Intake										
180 to 380mm Circ UL Duct	0	0	0	0	0	0	0	0		
10m	-1	-1	-1	-2	-2	-2	-2	-2		

200mm Circ/Rad. UL Elbow	0	0	-1	-2	-3	-3	-3	-3
4 bends	0	0	-4	-8	-12	-12	-12	-12
End Ref.Loss 0.04m2 (d=0.23)	-15	-10	-5	-2	-1	0	0	0
SUM	**-16**	**-11**	**-11**	**-14**	**-18**	**-17**	**-17**	**-17**
Discharge								
180 to 380mm Circ UL Duct	0	0	0	0	0	0	0	0
10m	-1	-1	-1	-2	-2	-2	-2	-2
200mm Circ/Rad. UL Elbow	0	0	-1	-2	-3	-3	-3	-3
4 bends	0	0	-4	-8	-12	-12	-12	-12
End Ref.Loss 0.04m2 (d=0.23)	-15	-10	-5	-2	-1	0	0	0
SUM	**-16**	**-11**	**-11**	**-14**	**-18**	**-17**	**-17**	**-17**
AHU04								
Intake								
300x300mm Rec UL Duct	-1	-1	0	0	0	0	0	0
5m	-6	-4	-2	-1	-1	-1	-1	-1
300mm Rec UL No TV Elbow	0	0	-1	-5	-8	-4	-3	-3
3 bends	0	0	-2	-10	-16	-8	-6	-6
End Ref.Loss 0.1m2 (d=0.36)	-11	-7	-3	-1	0	0	0	0
SUM	**-19**	**-11**	**-8**	**-17**	**-26**	**-13**	**-10**	**-10**
Discharge								
<180mm Circ UL Duct	0	0	0	0	0	0	0	0
5m	-1	-1	-1	-1	-2	-2	-2	-2
200mm Circ/Rad. UL Elbow	0	0	-1	-2	-3	-3	-3	-3
3 bends	0	0	-2	-4	-6	-6	-6	-6
End Ref.Loss 0.02m2 (d=0.16)	-18	-12	-7	-3	-1	0	0	0
SUM	**-18**	**-13**	**-12**	**-11**	**-12**	**-11**	**-11**	**-11**
SFB1								
Intake								
300x300mm Rec UL Duct	-1	-1	0	0	0	0	0	0
10m	-12	-7	-4	-2	-2	-2	-2	-2
300mm Rec UL Elbow w/TV	0	0	-1	-4	-6	-4	-4	-4
2 bends	0	0	-2	-8	-12	-8	-8	-8
End Ref.Loss 0.1m2 (d=0.36)	-11	-7	-3	-1	0	0	0	0
SUM	**-25**	**-14**	**-10**	**-15**	**-21**	**-14**	**-14**	**-14**
EF2.1								
Discharge								
300mm Rec UL No TV Elbow	0	0	-1	-5	-8	-4	-3	-3
End Ref.Loss 0.1m2 (d=0.36)	-11	-7	-3	-1	0	0	0	0
IL, Attenuator (2.1)	0	-10	-18	-29	-21	-17	-15	-13
SUM	**-11**	**-17**	**-22**	**-35**	**-29**	**-21**	**-18**	**-16**
EF0.1								
Discharge								
180 to 380mm Circ UL Duct	0	0	0	0	0	0	0	0
3m	0	0	0	-1	-1	-1	-1	-1
200mm Circ/Rad. UL Elbow	0	0	-1	-2	-3	-3	-3	-3
3 bends	0	0	-3	-6	-9	-9	-9	-9
End Ref.Loss 0.02m2 (d=0.16)	-18	-12	-7	-3	-1	0	0	0
SUM	-18	-13	-12	-12	-14	-13	-13	-13

Calculation

Using:

Lp(receptor) = Lw(unit) - DL + 10log(Q/(4πr^2)) + 10log(N) + FC - BA

Lp(receptor) = Sound pressure level at 1m from nearest noise sensitive receptor

Lw(unit) = Manufacturers sound power level of unit

DL = Attenuation provided by ductwork including silencers

10log(Q/(4πr^2)) = Attenuation due to distance, r (metres) and directivity factor, Q

10log(N) = correction for number of units

FC = Facade correction

BA = Barrier attenuation, calculated using path difference, PD (metres), between direct path and screened path

AHU01 - location L1 rooftop

To surroundings											
Lw(surroundings)	48	57	62	50	43	50	51	40	L_A=	58	
TL of enclosure	5	8	14	27	38	40	33	31			
10log(Q/(4πr^2))	-25	-25	-25	-25	-25	-25	-25	-25	Q=	2	r= 6.7
FC	3	3	3	3	3	3	3	3			
AHU01 Case radiated Lp(receptor)	21	27	26	1	-17	-12	-4	-13	L_A=	19	
Fresh air intake											
Lw(FAI)	50	51	51	45	39	44	48	46	L_A=	53	
DL	-8	-4	-2	-4	-7	-7	-7	-7			
10log(Q/(4πr^2))	-19	-19	-19	-19	-19	-19	-19	-19	Q=	2	r= 3.6
FC	3	3	3	3	3	3	3	3			
AHU01 FAI Lp(receptor)	26	31	33	24	16	21	25	23	L_A=	31	
Exhaust											
Lw(exhaust)	63	56	52	49	50	57	60	64	L_A=	66	
DL	-8	-4	-2	-4	-6	-4	-4	-4			
10log(Q/(4πr^2))	-24	-24	-24	-24	-24	-24	-24	-24	Q=	2	r= 6
BA [PD = 0.45m]	6	7	8	10	13	15	18	21			
FC	3	3	3	3	3	3	3	3			
AHU01 Exhaust Lp(receptor)	29	25	21	14	11	17	17	18	L_A=	24	
AHU2 - location Basement											
Fresh air intake											
Lw(FAI)	61	53	52	33	33	33	33	33	L_A=	46	
DL	-26	-15	-12	-29	-43	-22	-17	-17			
10log(Q/(4πr^2))	-20	-20	-20	-20	-20	-20	-20	-20	Q=	2	r= 4
FC	3	3	3	3	3	3	3	3			
AHU02 FAI Lp(receptor)	18	21	23	-13	-27	-6	-1	-1	L_A=	15	
Exhaust											
Lw(exhaust)	64	59	58	48	33	33	41	39	L_A=	52	
DL	-26	-15	-12	-29	-43	-22	-17	-17			
10log(Q/(4πr^2))	-24	-24	-24	-24	-24	-24	-24	-24	Q=	2	r= 6
BA [PD = 0.45m]	6	7	8	10	13	15	18	21			
FC	3	3	3	3	3	3	3	3			
AHU02 Exhaust Lp(receptor)	12	17	17	-11	-43	-25	-15	-20	L_A=	9	
AHU3 - Basement plant room											
Fresh air intake											
Lw(FAI)	83	75	74	55	55	55	55	55	L_A=	68	
DL	-16	-11	-11	-14	-18	-17	-17	-17			
10log(Q/(4πr^2))	-34	-34	-34	-34	-34	-34	-34	-34	Q=	2	r= 20
BA [PD = 0.01m]	5	5	5	6	6	7	8	10			
FC	3	3	3	3	3	3	3	3			
AHU03 FAI Lp(receptor)	31	28	26	4	0	0	-2	-3	L_A=	19	
Exhaust											
Lw(exhaust)	67	62	61	51	36	36	44	42	L_A=	55	
DL	-16	-11	-11	-14	-18	-17	-17	-17			
10log(Q/(4πr^2))	-35	-35	-35	-35	-35	-35	-35	-35	Q=	2	r= 23
BA [PD = 0.2m]	6	7	9	11	14	17	20	23			
FC	3	3	3	3	3	3	3	3			
AHU03 Exhaust Lp(receptor)	12	12	9	-7	-28	-30	-25	-30	L_A=	2	
AHU4 - GF Storeroom											
Fresh air intake											
Lw(FAI)	74	66	65	46	46	46	46	46	L_A=	59	
DL	-19	-11	-8	-17	-26	-13	-10	-10			
10log(Q/(4πr^2))	-31	-31	-31	-31	-31	-31	-31	-31	Q=	4	r= 20
BA [PD = 0.01m]	5	5	5	6	6	7	8	10			
FC	3	3	3	3	3	3	3	3			
AHU04 FAI Lp(receptor)	22	22	23	-5	-13	-2	0	-2	L_A=	16	
Exhaust											
Lw(exhaust)	60	55	54	44	29	29	37	35	L_A=	48	
DL	-18	-13	-12	-11	-12	-11	-11	-11			

10log(Q/(4πr^2))	-35	-35	-35	-35	-35	-35	-35	-35	Q=	2	r= 23
BA [PD = 0.2m]	6	7	9	11	14	17	20	23			
FC	3	3	3	3	3	3	3	3			
AHU04 Exhaust Lp(receptor)	3	3	1	-10	-29	-31	-26	-31	L_A=	-5	
Kitchen Supply fan											
Fresh air intake											
Lw(FAI)	60	70	61	61	52	51	49	47	L_A=	62	
DL	-25	-14	-10	-15	-21	-14	-14	-14			
10log(Q/(4πr^2))	-34	-34	-34	-34	-34	-34	-34	-34	Q=	2	r= 21
FC	3	3	3	3	3	3	3	3			
SFB.1 FAI Lp(receptor)	4	24	19	14	0	5	3	1	L_A=	16	
Kitchen extract fan											
Exhaust											
Lw(exhaust)	84	77	79	70	63	61	53	45	L_A=	73	
DL	-11	-17	-22	-35	-29	-21	-18	-16			
10log(Q/(4πr^2))	-37	-37	-37	-37	-37	-37	-37	-37	Q=	2	r= 27
BA [PD = 0.2m]	6	7	9	11	14	17	20	23			
FC	3	3	3	3	3	3	3	3			
EF2.1 Exhaust Lp(receptor)	32	19	14	-10	-14	-11	-19	-28	L_A=	10	
Surroundings											
Lw(surroundings)	59	53	60	51	55	49	48	45	L_A=	58	
10log(Q/(4πr^2))	-34	-34	-34	-34	-34	-34	-34	-34	Q=	4	r= 27
BA [PD = 0.2m]	6	7	9	11	14	17	20	23			
FC	3	3	3	3	3	3	3	3			
EF2.1 Case Lp(receptor)	22	15	20	9	10	1	-3	-9	L_A=	15	
EF0.1											
Discharge											
Lw(discharge)	0	64	56	53	52	49	42	34	L_A=	57	
DL	-18	-13	-12	-12	-14	-13	-13	-13			
10log(Q/(4πr^2))	-35	-35	-35	-35	-35	-35	-35	-35	Q=	2	r= 23
BA [PD = 0.2m]	6	7	9	11	14	17	20	23			
FC	3	3	3	3	3	3	3	3			
EF0.1 Exhaust Lp(receptor)	-57	12	3	-2	-8	-13	-23	-34	L_A=	1	
Chiller											
Lw(unit)	82	78	73	69	67	64	58	53	L_A=	72	
Enclosure	5	8	14	27	38	40	33	31			
10log(Q/(4πr^2))	-29	-29	-29	-29	-29	-29	-29	-29	Q=	2	r= 11
BA [PD = 0.003m]	5	5	5	5	5	6	6	7			
FC	3	3	3	3	3	3	3	3			
Chiller Lp(receptor)	46	39	28	11	-3	-8	-7	-11	L_A=	25	
Summary of levels											
AHU01 Case radiated Lp(receptor)	21	27	26	1	-17	-12	-4	-13	L_A=	19	
AHU01 FAI Lp(receptor)	26	31	33	24	16	21	25	23	L_A=	31	
AHU01 Exhaust Lp(receptor)	29	25	21	14	11	17	17	18	L_A=	24	
AHU03 FAI Lp(receptor)	31	28	26	4	0	0	-2	-3	L_A=	19	
AHU03 Exhaust Lp(receptor)	12	12	9	-7	-28	-30	-25	-30	L_A=	2	
AHU04 FAI Lp(receptor)	22	22	23	-5	-13	-2	0	-2	L_A=	16	
AHU04 Exhaust Lp(receptor)	3	3	1	-10	-29	-31	-26	-31	L_A=	-5	
SFB.1 FAI Lp(receptor)	4	24	19	14	0	5	3	1	L_A=	16	
EF2.1 Exhaust Lp(receptor)	32	19	14	-10	-14	-11	-19	-28	L_A=	10	
EF2.1 Case Lp(receptor)	22	15	20	9	10	1	-3	-9	L_A=	15	
EF0.1 Exhaust Lp(receptor)	-57	12	3	-2	-8	-13	-23	-34	L_A=	1	
Chiller Lp(receptor)	46	39	28	11	-3	-8	-7	-11	L_A=	25	
Total Lp(receptor)	**46**	**40**	**36**	**26**	**18**	**23**	**26**	**24**	**L_A=**	**33**	