Acoustic Consultancy Report

81238/3/1/9

External Plant Assessment - Issue 3

Report Prepared For

Savills Commercial Ltd
Summit House
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Contents

i) Executive Summary

New mechanical plant is to be installed at Summit House, in London.

LCP has been commissioned to carry out an acoustic environment survey and to use the obtained data to assess the potential noise impact of the plant installation on surrounding noise sensitive receptors.

The design criterion is as follows:

Day:	49 dB $L_{Aeq, T}$ at 20m, Halsey House, 13 Red Lion Square;
Day:	49 dB $L_{Aeq, T}$ at 10 Red Lion Square.

This report concludes that the current design, inclusive of the mitigation detailed in section 5 of this report, can achieve London Borough of Camden requirements. The calculated rating levels are as follows:

Day:	49 dB $L_{Aeq, T}$ at 20m, Halsey House, 13 Red Lion Square;
Day:	46 dB $L_{Aeq, T}$ at 10 Red Lion Square.

This report concludes that the design criteria can be achieved.

The calculated levels also show an indication of low impact in accordance with BS4142 and are acceptable according to BS8233 and WHO Guidelines for Community Noise.

ii) Document History

Issue	Date	Issue Details	Issued by
1	16th December 2016	Initial Issue	JN
2	4th January 2017	Updated plant layout and inclusion of tenant condensers	JN
3	5th January 2017	Minor changes	JN

1 Introduction

New mechanical plant is to be installed at Summit House, in London.

LCP has been commissioned by Norman Disney & Young to carry out an acoustic environment survey and to use the obtained data to assess the potential noise impact of the plant installation on surrounding noise sensitive receptors.

The report details recommendations for necessary noise mitigation where necessary.

The guidance contained in this report is given on the basis that the operational period of the plant may potentially be continuous between 07:00 and 19:00.

2 Survey

2.1 Site Description

The site layout together with the measurement position is shown in the drawing contained within Appendix A.

2.2 Receiver Location

The site was surveyed to determine the location of the most affected receiver.

The nearest receivers to the plant area is 20m to the east of the site at Halsey House and 10m to the west of the site at 10 Red Lion Square. The receivers do not have direct line of sight to all plant.

2.3 Local Noise Climate

The predominant local noise source was road traffic noise from the A40.

2.4 Measurements

The noise monitoring took place from 17th to 18th November 2016. The measurement period was considered sufficient to establish the representative background sound levels corresponding to the operational period of the plant.

The weather conditions monitored during the survey are shown in the following table.

Table 1: Weather Conditions at Measurement Location

Weather	Value
Average Wind Speed	3m/s
Wind Direction	SW
Cloud Cover	75%
Max. Temperature	9°C
Min. Temperature	3°C
Precipitation	None

2.5 Measurement Results

The measured statistical broad-band sound pressure levels are shown within Appendix C. The representative background sound level(s) obtained being as follows:

Table 2: Representative background sound levels, dB re 2x10^{-5} Pa

Measurement Position	$L_{A90,\ 15\ mins}$ Day*	$L_{A90,\ 15\ mins}$ Evening*	$L_{A90,\ 15\ mins}$ Night*
MP1	54	51	47

* Day, Evening and Night periods are defined as between 07:00 - 19.00, 19.00 - 23.00 and 23:00 - 07:00 respectively.

3 Evaluation of Design Criteria

3.1 BS4142:2014

BS4142:2014 states that 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.

Table 3: BS4142 assessment based upon rating level

Difference between background noise and rating levels	Assessment
+ 10 dB	Indication of a significant adverse impact
+ 5 dB	Indication of an adverse impact
0 dB	Indication of low impact

Certain acoustic features can increase the significance of impact. The specific sound level should be corrected if a tone, impulse or other acoustic feature is expected to be present.

Table 4: Corrections for acoustic features, subjective method

Acoustic Feature	Correction, dB		
	Just Perceptible	Clearly Perceptible	Highly Perceptible
Tonality	2	4	6
Impulsivity	3	6	9
Other Characteristics	3		
Intermittency	3		

Typically, the acoustic feature correction would not be expected to exceed 10dB.

Where the level of uncertainty could affect the conclusion, take reasonably practicable steps to reduce the level of uncertainty.

3.2 World Health Organisation Night Noise Guidelines for Europe (2009)

The WHO's document 'Night Noise Guidelines for Europe (NNG) states the following:

"*…it is recommended that the population should not be exposed to night noise levels greater than 40 dB of $L_{night,\ outside}$ during the part of the night when most people are in bed*."

It then goes on to say:

"*An interim target (IT) if 55 dB $L_{night,\ outside}$ is recommended in the situations where the achievement of NNG is not feasible in the short run for various reasons*."

As the above guideline values consider the combined level of noise external to a façade (i.e. vehicular traffic, air traffic, building services noise etc, it is recommended that a criterion of 10 dB below these given levels is applied, depending on the particulars of the site in question.

3.3 World Health Organisation (WHO) Guidelines for Community Noise (1999)

The WHO's 'Guidelines for Community Noise' gives the following relevant noise criteria:

Table 5: Guideline values for community noise, from Guidelines for Community Noise (WHO, 1999)

Specific Environment	$L_{Aeq,\ T}$ dB	Time Base (hours)	L_{AFMax}, fast dB
Outdoor living area (serious annoyance, daytime and evening)	55	16	-
Outdoor living area (moderate annoyance, daytime and evening)	50	16	-
Dwelling, indoors	35	16	-
Inside bedrooms	30	8	45
Outside bedrooms	45	8	60
Outdoors in parkland and conservation areas*	-	-	-

* Existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low

The WHO's 'Guidelines for Community Noise' also gives the following general guidance on the expected sound insulation performance of a façade with a partly open window, it states that:
"*At night, sound pressure levels at the outside facades of the living spaces should not exceed 45 dB L_{Aeq} and 60 dB L_{Amax}, so that people may sleep with bedroom windows open. These values have been obtained by assuming that the noise reduction from outside to inside with the window partly open is 15 dB.*"

3.4 BS8233:2014

The criteria offered in BS8233 for residential buildings are largely based on the recommendations made in the Guidelines for Community Noise.

Using the general guidance from above, on the expected sound insulation performance of a façade with a partly open window, the criteria shown in the table below have been adapted from the criteria offered in table

4 of BS8233 in order to obtain acceptable external noise levels. The noise levels shown should be treated as overall noise levels, i.e., the combination of all existing noise levels at the site, and noise levels from any proposed plant or activity.

Table 6: External ambient noise levels for dwellings, based on BS8233, dB re 2x10^{-5} Pa

Activity	**Location**	**Time period**	
		07:00 to 23:00	**23:00 to 07:00**
Resting	Living Room	50 $L_{Aeq,16\ hour}$	-
Dining	Dining Room/area	55 $L_{Aeq,\ 16\ hour}$	-
Sleeping (daytime resting)	Bedroom	50 $L_{Aeq,\ 16\ hour}$	45 $L_{Aeq,\ 8\ hour}$

In addition to the above criteria, BS8233 goes on to say:
"*For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 $L_{Aeq,\ T}$, with an upper guideline value of 55 dB $L_{Aeq,\ T}$ which would be acceptable in nosier environments*."

The above criteria are in line with the recommendations made in WHO's 'Guidelines for Community Noise'.

3.5 Local Authority Requirements

The London Borough of Camden conditions state that the noise level from any fixed mechanical plant/activity shall not exceed 5 dB below the measured background noise level, day evening or night, at 1m externally to the nearest noise sensitive facade.

Where mechanical plant is tonal or intermittent, the design criterion must be reduced by a further 5 dB.

A noise sensitive development includes housing, schools, hospitals, offices, workshops and open spaces.

3.6 Design Rating Level

On the basis of the above the recommended design rating level should therefore be:

Residential Design Rating Level
Representative $L_{A90,\ 15\ mins}$ - 5 dB

The design levels to be adopted for this project are set out in the table below.

Table 7: Design rating levels, dB re 2x10^{-5} Pa

Receiver Premises	**Approximate Distance (m)**	**Design Level (Day) $L_{Aeq,\ 12\ hr}$**	**Design Level (Evening) $L_{Aeq,\ 4\ hr}$**	**Design Level (Night) $L_{Aeq,\ 8\ hr}$**
Halsey House, 13 Red Lion Square	20	49	46	42
10 Red Lion Square	10	49	46	42

4 Review of Current Design

4.1 Current Design

The proposed plant shall be located on the roof, plant includes three Air Handling Units, one Chiller and eight tenant Condensers. Plant will operate between the hours of 07:00 and 19:00 only.

4.2 Calculated Results

Calculations of the predicted noise levels have been carried out with the appropriate corrections for geometric attenuation, barrier effect, reflective surfaces and multiple source addition. The design rating levels to be adopted for this project, together with the predicted noise levels, are set out in the following table.

Table 8: Design and predicted rating levels, dB re $2x10^{-5}$ Pa

Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq, 12 hr}$	Predicted Level $L_{Aeq, T}$
Halsey House, 13 Red Lion Square	20	49	60
10 Red Lion Square	10	49	58

5 Noise Mitigation

As the plant installation has been assessed to be over the required criteria at the surrounding noise sensitive receptors, the following options shall be applied in order that noise emissions are reduced to acceptable levels.

It is important to note that as the criteria is a single figure dB(A) value, the performance of any enclosure, screen or attenuator at each individual frequency can vary from those shown above and still meet the single figure dB(A) value.

Should the plant installation be redesigned after consideration of the mitigation options, the installation shall be re-assessed to ensure compliance to the specification has been achieved.

5.1 Chiller Screening

The first advised form of mitigation is the introduction of an acoustic louvered screen surrounding the chiller, with a minimum height 400mm above the chiller. The advised acoustic louvre performance is shown in the table below.

Table 9: Advised acoustic louvre sound reduction performance, dB

Louvre	Octave Band Centre Frequency (Hz)								R_w
	63	125	250	500	1k	2k	4k	8k	
SS300*	6	6	9	13	21	20	16	13	18

* data taken from Caice

The design of the mitigation will need the services of a noise control company, such a company would visit the site and attempt to arrive at an economic solution, taking into account all the parameters of this particular situation. The problems of air flow, pressure drop etc, applicable to this equipment will all need to be taken into account. Such a company is:

Company	Address	Telephone	Email/Web
Caice	Riverside House, 3 Winnersh Fields Winnersh, Wokingham, RG41 5QS	0118 918 6470	enquiries@caice.co.uk www.caice.co.uk

5.2 AHU Attenuation

In addition, the second advised form of mitigation is that all air handling units are attenuated on the fresh air inlet and extract exhaust terminals. Advised attenuator insertion loss performances are provided in the following table.

Table 10: Advised attenuator insertion losses, dB

Plant	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
AHU 1 Intake/Exhaust	4	8	16	24	19	12	9	6
AHU 2 Intake/Exhaust	6	8	15	32	44	27	16	12
AHU 3 Intake/Exhaust	3	9	14	27	28	18	11	6

The manufacturer/supplier of any attenuators shall ensure that the air volumes through all attenuators and the configurations of the attenuators will not create regenerated noise. Alternative configurations may have to be selected.

It is recommended that all attenuator performances are verified by test data in accordance with ISO 7235.

5.3 Mitigated Results

The design rating levels to be adopted for this project, together with the predicted noise levels inclusive of the mitigation detailed in Section 5, are set out in the table below.

Table 11: Design and predicted mitigated rating levels, dB re $2x10^{-5}$ Pa

Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq, 12 hr}$	Predicted Level $L_{Aeq, T}$
Halsey House, 13 Red Lion Square	20	49	49
10 Red Lion Square	10	49	46

Plant noise level data used in this assessment are contained within Appendix C. Calculations are shown within Appendix D.

6 Conclusion

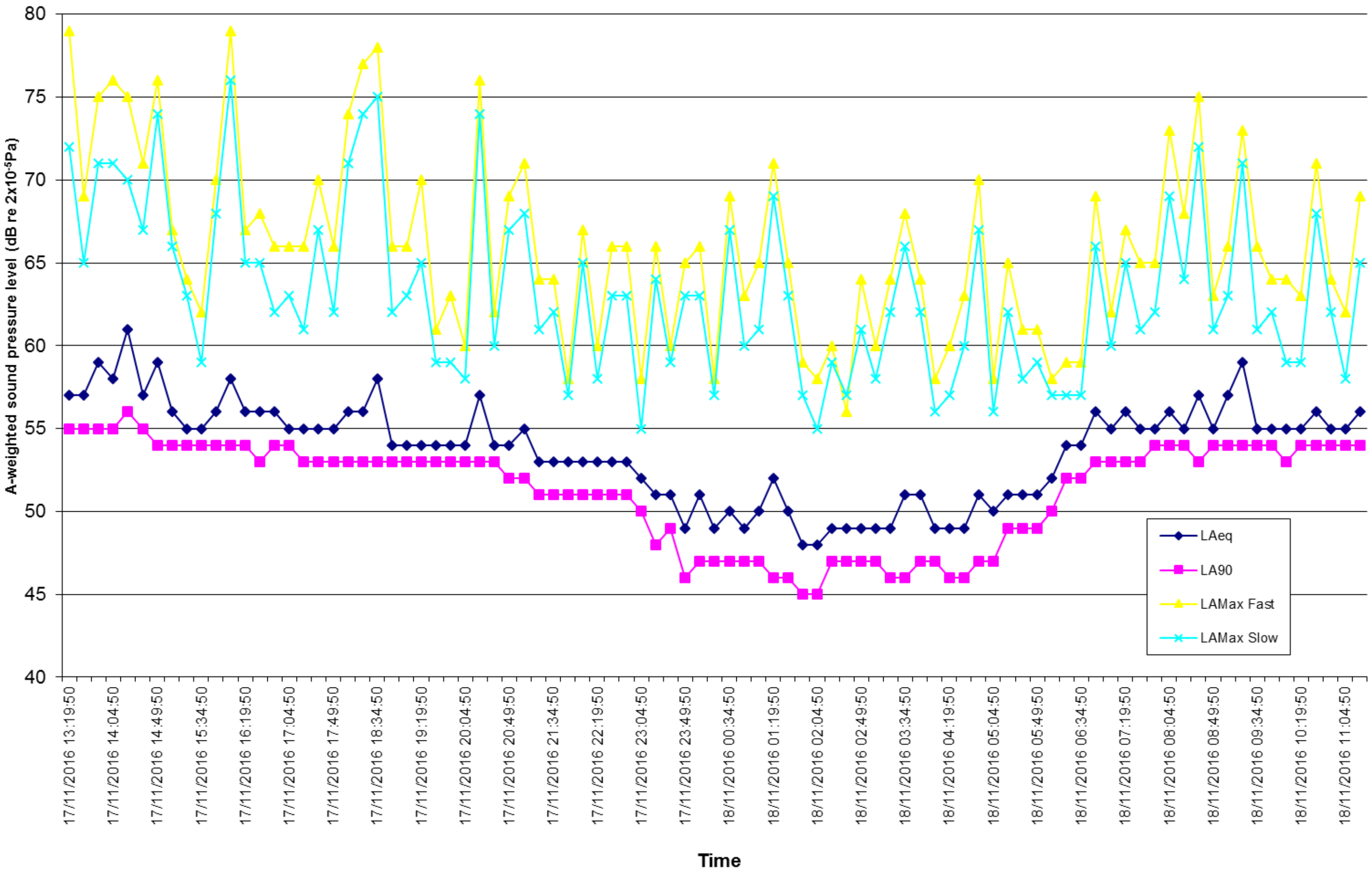
An environmental noise survey has been undertaken in order to establish the representative background sound levels local to the site generally in accordance with the method contained within BS4142: 2014.

Calculations have been carried out to determine the noise levels at the nearest receiver premises. The calculations show that with the implementation of the noise mitigation measures detailed in section 5 of this report the design can achieve London Borough of Camden requirements.

The calculated levels also show an indication of low impact in accordance with BS4142 and are acceptable according to BS8233 and WHO Guidelines for Community Noise.

Appendix A: Site Plan

Appendix B: Measurement Data



Sound pressure level measurements were obtained using the following instrumentation complying with the Class 1 specification of BS EN 61672:2003

- Svantek 959 Sound Level Meter S/N: 11258
- Svantek pre-amplifier SV12L S/N: 13111 with GRAS microphone capsule 40AE S/N: 86548

Calibration checks were made prior to and after completion of measurements using a Svantek SV33 calibrator, S/N: 43066 complying with Class 1 specification of BS EN 60942:2003, calibration level 114.0 dB @ 1.0 kHz. All acoustic instrumentation carried current manufacturer's certificates of conformance.

Appendix C: Plant Data

Plant noise data used in the preceding assessment follow.

Table 12: Manufacturer's plant sound power data, dB re 10^{-12} W

Plant	Octave Band Centre Frequency (Hz)								L_{WA}
	63	125	250	500	1k	2k	4k	8k	
Chiller	84	83	86	88	89	77	67	59	91
AHU 1 Intake	66	72	73	66	58	59	55	51	69
AHU 1 Exhaust	69	75	76	76	76	75	71	66	81
AHU 1 Breakout	63	65	64	51	45	47	44	32	58
AHU 2 Intake	68	74	78	71	63	64	57	52	73
AHU 2 Exhaust	72	77	78	80	79	78	74	70	84
AHU 2 Breakout	65	68	69	56	50	52	46	33	63
AHU 3 Intake	57	61	71	66	61	59	57	51	68
AHU 3 Exhaust	70	66	73	73	73	74	72	73	80
AHU 3 Breakout	57	62	67	55	46	51	48	33	61

Table 13: Manufacturer's plant sound pressure data, dB re $2x10^{-5}$ Pa

Plant	Distance (m)	Octave Band Centre Frequency (Hz)								L_{PA}
		63	125	250	500	1k	2k	4k	8k	
Tenant Condensers PUHZ-ZRP100VKA2	1	58	52	49	48	46	40	34	37	51

Appendix D: Calculations

Halsey House (including mitigation):

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw) 63	125	250	500	1k	2k	4k	8k	dB(A)	Lw dB(A)	Reciever Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality
1	Chiller		84	83	86	88	89	77	67	59	91	91	17.0	-33	58	1	0	45(-3dB)
2	AHU 1 Intake		66	72	73	66	58	59	55	51	69	69	26.0	-36	32	1	0	90(-6dB)
3	AHU 1 Exhaust		69	75	76	76	76	75	71	66	81	81	26.0	-36	45	1	0	90(-6dB)
4	AHU 1 Breakout		63	65	64	51	45	47	44	32	58	58	26.0	-36	22	1	0	None
5	AHU 2 Intake		68	74	78	71	63	64	57	52	73	73	16.0	-32	41	1	0	90(-6dB)
6	AHU 2 Exhaust		72	77	78	80	79	78	74	70	84	84	16.0	-32	52	1	0	90(-6dB)
7	AHU 2 Breakout		65	68	69	56	50	52	46	33	63	63	16.0	-32	30	1	0	None
8	AHU 3 Intake		57	61	71	66	61	59	57	51	68	68	16.0	-32	36	1	0	90(-6dB)
9	AHU 3 Exhaust		70	66	73	73	73	74	72	73	80	80	16.0	-32	48	1	0	90(-6dB)
10	AHU 3 Breakout		57	62	67	55	46	51	48	33	61	61	16.0	-32	29	1	0	None
11	Tenant Condensers	1.00	58	52	49	48	46	40	34	37	50	58	19.0	-34	25	8	9	None

Ref.	plant	63	125	250	500	1k	2k	4k	8k	Façade correction	dB	Line of Sight Losses 63	125	250	500	1k	2k	4k	8k	Additional Attenuation 63	125	250	500	1k	2k	4k	8k
1	Chiller	-3	-3	-3	-3	-3	-3	-3	-3	Yes	3	-3	0	0	0	0	0	0	0								
2	AHU 1 Intake	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-5	-5	-5	-4	-4	-3	-1	0	4	8	16	24	19	12	9	6
3	AHU 1 Exhaust	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-4	-4	-3	-1	0	0	0	0	4	8	16	24	19	12	9	6
4	AHU 1 Breakout	0	0	0	0	0	0	0	0	Yes	3	-4	-3	-1	0	0	0	0	0								
5	AHU 2 Intake	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-5	-4	-4	-3	0	0	0	0	6	8	15	32	44	27	16	2
6	AHU 2 Exhaust	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-3	0	0	0	0	0	0	0	6	8	15	32	44	27	16	2
7	AHU 2 Breakout	0	0	0	0	0	0	0	0	Yes	3	0	0	0	0	0	0	0	0								
8	AHU 3 Intake	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-5	-4	-4	-3	0	0	0	0	3	9	14	27	28	18	11	6
9	AHU 3 Exhaust	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3	-3	0	0	0	0	0	0	0	3	9	14	27	28	18	11	6
10	AHU 3 Breakout	0	0	0	0	0	0	0	0	Yes	3	0	0	0	0	0	0	0	0								
11	Tenant Condensers	0	0	0	0	0	0	0	0	Yes	3	-4	-4	-2	0	0	0	0	0								

Ref.	plant	Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	51	50	53	55	56	44	34	26	58
2	AHU 1 Intake	27	33	34	27	19	20	16	12	29
3	AHU 1 Exhaust	30	36	37	37	37	36	32	27	42
4	AHU 1 Breakout	30	32	31	18	12	14	11	-1	25
5	AHU 2 Intake	33	39	43	36	28	29	22	17	38
6	AHU 2 Exhaust	37	42	43	45	44	43	39	35	49
7	AHU 2 Breakout	36	39	40	27	21	23	17	4	33
8	AHU 3 Intake	22	26	36	31	26	24	22	16	33
9	AHU 3 Exhaust	35	31	38	38	38	39	37	38	45
10	AHU 3 Breakout	28	33	38	26	17	22	19	4	32
11	Tenant Condensers	47	41	38	37	35	29	23	26	40
	Total	**54**	**53**	**56**	**57**	**58**	**49**	**43**	**41**	**60**

Barrier Path Difference Loss: Source height	Receiver height	Barrier height	Source to barrier distance	Barrier to receiver distance	Calculated path difference	63	125	250	500	1000	2000	4000	8000
18.0	15.0	18.4	0.5	16.5	0.22	-7	-8	-10	-12	-15	-17	-20	-23
15.5	15.0			26.0	-19.51	0	0	0	0	0	0	0	0
16.5	15.0			26.0	-20.47	0	0	0	0	0	0	0	0
17.0	15.0			26.0	-20.94	0	0	0	0	0	0	0	0
15.5	15.0			16.0	-21.42	0	0	0	0	0	0	0	0
16.5	15.0			16.0	-22.36	0	0	0	0	0	0	0	0
17.0	15.0			16.0	-22.81	0	0	0	0	0	0	0	0
15.5	15.0			16.0	-21.42	0	0	0	0	0	0	0	0
16.5	15.0			16.0	-22.36	0	0	0	0	0	0	0	0
17.0	15.0			16.0	-22.81	0	0	0	0	0	0	0	0
16.2	15.0			19.0	-21.37	0	0	0	0	0	0	0	0

Criteria NR	63	125	250	500	1k	2k	4k	8k	dB(A)
41	68	58	50	45	41	38	36	34	49

Barrier SRI	63	125	250	500	1k	2k	4k	8k
Manual								
SS300	6	6	9	13	21	20	16	13

Ref.	Plant	Excess 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	-16	-7	3	11	15	6	-2	-8	9
2	AHU 1 Intake	-41	-25	-16	-18	-22	-18	-20	-23	-20
3	AHU 1 Exhaust	-38	-22	-13	-8	-4	-2	-4	-8	-8
4	AHU 1 Breakout	-38	-26	-19	-27	-29	-24	-25	-36	-25
5	AHU 2 Intake	-35	-19	-7	-9	-13	-9	-14	-17	-11
6	AHU 2 Exhaust	-31	-16	-7	0	3	5	3	1	0
7	AHU 2 Breakout	-32	-19	-10	-18	-20	-15	-19	-30	-16
8	AHU 3 Intake	-46	-32	-14	-14	-15	-14	-14	-18	-16
9	AHU 3 Exhaust	-33	-27	-12	-7	-3	1	1	4	-4
10	AHU 3 Breakout	-40	-25	-12	-19	-24	-16	-17	-30	-18
11	Tenant Condensers	-20	-16	-12	-7	-6	-9	-12	-8	-10
	Total	-14	-4	6	12	17	11	8	7	11

Barrier Deration								
Chiller	3	4	3	3	1	2	6	11
AHU 1 Intake	1	1	1	0	0	0	0	0
AHU 1 Exhaust	1	1	1	0	0	0	0	0
AHU 1 Breakout	1	1	1	0	0	0	0	0
AHU 2 Intake	1	1	1	0	0	0	0	0
AHU 2 Exhaust	1	1	1	0	0	0	0	0
AHU 2 Breakout	1	1	1	0	0	0	0	0
AHU 3 Intake	1	1	1	0	0	0	0	0
AHU 3 Exhaust	1	1	1	0	0	0	0	0
AHU 3 Breakout	1	1	1	0	0	0	0	0
Tenant Condensers	1	1	1	0	0	0	0	0

Ref.	Plant	Mitigated Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	45	46	47	46	43	29	20	14	47
2	AHU 1 Intake	19	21	14	-2	-4	4	5	6	13
3	AHU 1 Exhaust	22	25	19	12	18	24	23	21	29
4	AHU 1 Breakout	27	29	30	18	12	14	11	-1	24
5	AHU 2 Intake	23	28	25	1	-16	2	6	15	20
6	AHU 2 Exhaust	29	35	29	13	0	16	23	33	33
7	AHU 2 Breakout	37	40	41	27	21	23	17	4	34
8	AHU 3 Intake	15	14	19	1	-2	6	11	10	16
9	AHU 3 Exhaust	30	23	25	11	10	21	26	32	33
10	AHU 3 Breakout	29	34	39	26	17	22	19	4	32
11	Tenant Condensers	44	39	38	37	35	29	23	26	40
	Total	**49**	**49**	**50**	**48**	**45**	**35**	**32**	**37**	**49**

Net barrier loss								
Chiller	**-4**	**-4**	**-7**	**-9**	**-14**	**-15**	**-14**	**-12**
AHU 1 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 1 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 1 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
Tenant Condensers	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**

10 Red Lion Square (including mitigation):

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw) 63	125	250	500	1k	2k	4k	8k	dB(A)	Lw dB(A)	Reciever Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality
1	Chiller		84	83	86	88	89	77	67	59	91	91	7.0	-25	66	1	0	90(-6dB)
2	AHU 1 Intake		66	72	73	66	58	59	55	51	69	69	10.0	-28	41	1	0	90(-6dB)
3	AHU 1 Exhaust		69	75	76	76	76	75	71	66	81	81	10.0	-28	53	1	0	90(-6dB)
4	AHU 1 Breakout		63	65	64	51	45	47	44	32	58	58	7.0	-25	33	1	0	90(-6dB)
5	AHU 2 Intake		68	74	78	71	63	64	57	52	73	73	18.0	-33	40	1	0	45(-3dB)
6	AHU 2 Exhaust		72	77	78	80	79	78	74	70	84	84	18.0	-33	51	1	0	45(-3dB)
7	AHU 2 Breakout		65	68	69	56	50	52	46	33	63	63	23.0	-35	27	1	0	45(-3dB)
8	AHU 3 Intake		57	61	71	66	61	59	57	51	68	68	22.0	-35	33	1	0	90(-6dB)
9	AHU 3 Exhaust		70	66	73	73	73	74	72	73	80	80	22.0	-35	45	1	0	90(-6dB)
10	AHU 3 Breakout		57	62	67	55	46	51	48	33	61	61	15.0	-32	29	1	0	45(-3dB)
11	Tenant Condensers	1.00	58	52	49	48	46	40	34	37	50	58	15.0	-32	27	8	9	90(-6dB)

Ref.	plant	63	125	250	500	1k	2k	4k	8k	Façade correction	dB
1	Chiller	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
2	AHU 1 Intake	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
3	AHU 1 Exhaust	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
4	AHU 1 Breakout	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
5	AHU 2 Intake	-3	-3	-3	-3	-3	-3	-3	-3	Yes	3
6	AHU 2 Exhaust	-3	-3	-3	-3	-3	-3	-3	-3	Yes	3
7	AHU 2 Breakout	-3	-3	-3	-3	-3	-3	-3	-3	Yes	3
8	AHU 3 Intake	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
9	AHU 3 Exhaust	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3
10	AHU 3 Breakout	-3	-3	-3	-3	-3	-3	-3	-3	Yes	3
11	Tenant Condensers	-6	-6	-6	-6	-6	-6	-6	-6	Yes	3

Ref.	plant	Line of Sight Losses 63	125	250	500	1k	2k	4k	8k	Additional Attenuation 63	125	250	500	1k	2k	4k	8k
1	Chiller	-7	-9	-11	-14	-16	-19	-22	-24								
2	AHU 1 Intake	0	0	0	0	0	0	0	0	4	8	16	24	19	12	9	6
3	AHU 1 Exhaust	0	0	0	0	0	0	0	0	4	8	16	24	19	12	9	6
4	AHU 1 Breakout	-7	-9	-11	-14	-16	-19	-22	-24								
5	AHU 2 Intake	0	0	0	0	0	0	0	0	6	8	15	32	44	27	16	2
6	AHU 2 Exhaust	0	0	0	0	0	0	0	0	6	8	15	32	44	27	16	2
7	AHU 2 Breakout	0	0	0	0	0	0	0	0								
8	AHU 3 Intake	0	0	0	0	0	0	0	0	3	9	14	27	28	18	11	6
9	AHU 3 Exhaust	0	0	0	0	0	0	0	0	3	9	14	27	28	18	11	6
10	AHU 3 Breakout	0	0	0	0	0	0	0	0								
11	Tenant Condensers	-13	-15	-18	-21	-24	-24	-24	-24								

Ref.	plant	Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	56	55	58	60	61	49	39	31	63
2	AHU 1 Intake	35	41	42	35	27	28	24	20	38
3	AHU 1 Exhaust	38	44	45	45	45	44	40	35	50
4	AHU 1 Breakout	35	37	36	23	17	19	16	4	30
5	AHU 2 Intake	35	41	45	38	30	31	24	19	40
6	AHU 2 Exhaust	39	44	45	47	46	45	41	37	51
7	AHU 2 Breakout	30	33	34	21	15	17	11	-2	27
8	AHU 3 Intake	19	23	33	28	23	21	19	13	30
9	AHU 3 Exhaust	32	28	35	35	35	36	34	35	42
10	AHU 3 Breakout	25	30	35	23	14	19	16	1	29
11	Tenant Condensers	44	38	35	34	32	26	20	23	36
	Total	**60**	**59**	**62**	**63**	**64**	**55**	**48**	**44**	**67**

Barrier Path Difference Loss: Source height	Receiver height	Barrier height	Source to barrier distance	Barrier to receiver distance	Calculated path difference	63	125	250	500	1000	2000	4000	8000
18.0	18.0	18.4	1.0	6.0	0.09	-6	-6	-8	-9	-11	-14	-17	-19
15.5	18.0			10.0	-25.78	0	0	0	0	0	0	0	0
16.5	18.0			10.0	-26.98	0	0	0	0	0	0	0	0
17.0	18.0			7.0	-29.24	0	0	0	0	0	0	0	0
15.5	18.0			18.0	-22.78	0	0	0	0	0	0	0	0
16.5	18.0			18.0	-23.89	0	0	0	0	0	0	0	0
17.0	18.0			23.0	-23.18	0	0	0	0	0	0	0	0
15.5	18.0			22.0	-21.78	0	0	0	0	0	0	0	0
16.5	18.0			22.0	-22.87	0	0	0	0	0	0	0	0
17.0	18.0			15.0	-25.40	0	0	0	0	0	0	0	0
16.2	18.0			15.0	-24.52	0	0	0	0	0	0	0	0

Criteria NR	63	125	250	500	1k	2k	4k	8k	dB(A)
41	68	58	50	45	41	38	36	34	49

Barrier SRI	63	125	250	500	1k	2k	4k	8k
Manual								
SS300	6	6	9	13	21	20	16	13

Ref.	Plant	Excess 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	-12	-3	8	15	20	11	3	-3	14
2	AHU 1 Intake	-33	-17	-8	-10	-14	-10	-12	-14	-12
3	AHU 1 Exhaust	-30	-14	-5	0	4	6	4	1	1
4	AHU 1 Breakout	-33	-21	-14	-22	-24	-19	-20	-30	-19
5	AHU 2 Intake	-33	-17	-5	-7	-11	-7	-12	-15	-9
6	AHU 2 Exhaust	-29	-14	-5	2	5	7	5	3	2
7	AHU 2 Breakout	-38	-25	-16	-24	-26	-21	-25	-36	-22
8	AHU 3 Intake	-49	-35	-17	-17	-18	-17	-17	-21	-19
9	AHU 3 Exhaust	-36	-30	-15	-10	-6	-2	-2	1	-7
10	AHU 3 Breakout	-42	-27	-15	-21	-27	-19	-19	-33	-20
11	Tenant Condensers	-24	-20	-16	-11	-9	-13	-16	-12	-14
	Total	-8	1	12	19	23	16	12	10	17

Barrier Deration								
Chiller	3	3	2	2	0	1	3	7
AHU 1 Intake	1	1	1	0	0	0	0	0
AHU 1 Exhaust	1	1	1	0	0	0	0	0
AHU 1 Breakout	1	1	1	0	0	0	0	0
AHU 2 Intake	1	1	1	0	0	0	0	0
AHU 2 Exhaust	1	1	1	0	0	0	0	0
AHU 2 Breakout	1	1	1	0	0	0	0	0
AHU 3 Intake	1	1	1	0	0	0	0	0
AHU 3 Exhaust	1	1	1	0	0	0	0	0
AHU 3 Breakout	1	1	1	0	0	0	0	0
Tenant Condensers	1	1	1	0	0	0	0	0

Ref.	Plant	Mitigated Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	Chiller	46	43	41	39	33	17	3	-5	39
2	AHU 1 Intake	32	34	27	11	8	16	15	14	24
3	AHU 1 Exhaust	35	37	30	21	26	32	31	29	37
4	AHU 1 Breakout	29	29	26	9	1	0	-6	-20	19
5	AHU 2 Intake	30	34	31	6	-14	4	8	17	25
6	AHU 2 Exhaust	34	37	31	15	2	18	25	35	35
7	AHU 2 Breakout	31	34	35	21	15	17	11	-2	28
8	AHU 3 Intake	17	15	20	1	-5	3	8	7	15
9	AHU 3 Exhaust	30	20	22	8	7	18	23	29	30
10	AHU 3 Breakout	26	31	36	23	14	19	16	1	30
11	Tenant Condensers	32	23	17	12	8	2	-4	-1	15
	Total	**50**	**49**	**47**	**43**	**37**	**36**	**36**	**40**	**46**

Net barrier loss								
Chiller	**-3**	**-3**	**-6**	**-7**	**-11**	**-13**	**-14**	**-12**
AHU 1 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 1 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 1 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 2 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Intake	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Exhaust	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
AHU 3 Breakout	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
Tenant Condensers	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**

Appendix E: Glossary

The list below details the major acoustical terms and descriptors, with brief definitions:

‘A’ Weighting

Weighting applied to the level in each stated octave band by a specified amount, in order to better represent the response of the human ear. The letter ‘A’ will follow a descriptor, indicating the value has been ‘A’ weighted. An ‘A’ weighted noise level may also be written as dB(A).

Airborne Noise

Noise transmitted through air.

Ambient Noise

The total noise level including all ‘normally experienced’ noise sources.

dB or Decibel

Literally meaning ‘a tenth of a bel’, the bel being a unit devised by the Bell Laboratory and named after Alexander Graham Bell. A logarithmically based descriptor to compare a level to a reference level. Decibel arithmetic is not linear, due to the logarithmic base. For example:

30 dB + 30 dB ≠ 60 dB	30 dB + 30 dB = 33 dB

$D_{nTw}+C_{tr}$

The weighted, normalised difference in airborne noise levels measured in a source room (L1) and a receive room (L2) due to a separating partition.

D	Is simply L1 – L2.
D_{nT}	Is the normalisation of the measured level difference to the expected (in comparison to the measured) reverberation time in the receiving room.
D_{nTw}	Is the weighted and normalised level difference. This value is the result of applying a known octave band weighting curve to the measured result.

C_{tr}	Is a correction factor applied to the D_{nTw} to account for the known effects of particular types of noise, such as loud stereo music or traffic noise.

Frequency (Hz)

Measured in Hertz (after Heinrich Hertz), and represents the number of cycles per second of a sound or tone.

Insertion Loss, dB

The amount of sound reduction offered by an attenuator or louvre once placed in the path of a noise level.

$L_{A90, T}$

The ‘A’ weighted noise level exceeded for 90% of the time period T, described or measured. The ‘90’ can be substituted for any value between 1 and 99 to indicate the noise level exceeded for the corresponding percentage of time described or measured.

$L_{Aeq, T}$

The ‘A’ weighted ‘equivalent’ noise level, or the average noise level over the time period T, described or measured.

L_{Amax}

The ‘A’ weighted maximum measured noise level. Can be measured with a ‘slow’ (1 sec) or ‘fast’ (0.125 sec) time weighting.

L_{Amin}

The ‘A’ weighted minimum measured noise level.

NR

Noise Rating (NR) level. A frequency dependent system of noise level curves developed by the International Organisation for Standardisation (ISO). NR is used to categorise and determine the acceptable indoor environment in terms of hearing preservation, speech communication and annoyance in any given application as a single figure level. The US predominantly uses the Noise Criterion (NC) system.

Octave

The interval between a frequency in Hz (f) and either half or double that frequency (0.5f or 2f).

Pa

Pascals, the SI unit to describe pressure, after physicist Blaise Pascal.

Reverberation Time, T_{mf}, RT60, RT30 or RT20

The time taken in seconds for a sound to diminish within a room by 1,000 times its original level, corresponding to a drop in sound pressure of 60 dB. When taking field measurements and where background noise levels are high, the units RT20 or RT30 are used (measuring drops of 20 or 30 dB respectively). Sometimes given as a mid-frequency reverberation time, T_{mf} which is the average of reverberation time values at 500Hz, 1kHz and 2kHz.

R_w

The sound reduction value(s) of a constructional element such as a door, as measured in a laboratory, with a known octave band weighting curve applied to the result.

Sound Power Level

A noise level obtained by calculation from measurement data, given at the face of an item of plant or machinery. Referenced to 10^{-12} W or 1pW.

Sound Pressure Level

A noise level measured or given at a distance from a source or a number of sources. Referenced to $2x10^{-5}$ Pa.

Subjective Effect of Changes in Sound Pressure Level

The table below details the subjective effects of variations in sound pressures (adapted from Bies and Hansen).

Difference between background noise and rating levels	Increase in ambient noise level in 'real terms'	Change in apparent loudness
+ 10 dB	+ 10 dB	Twice as loud
+ 5 dB	+ 6 dB	Clearly noticeable
0 dB	+ 3 dB	Just perceptible
-10 dB	0 dB	No change

W

Watts, the SI unit to describe power, after engineer James Watt.