Acoustic Assessment

18-23 Hand Court
High Holborn Estate
SRG Holborn Ltd.

26th September 2018

Acoustic Consultancy Report

89826/3/1/4
External Plant Assessment
18 - 23 Hand Court

Report Prepared For

G.D.M Pts.
19 September 2018

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i) Executive Summary

New mechanical plant is to be installed at 18-21 Hand Court, 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.

New mechanical plant will also be installed at a later date at 22-23 Hand court. The new plant will be the responsibility of the new tenants which will be required to undertake an assessment to ensure the noise criteria within this report is not exceeded.

The guidance contained in this report is given on the basis that the plant may be consistently operating between 07:00 and 23:00.

The design criterion is as follows:

Day:	39 dB $L_{Aeq,\,T}$ at 20m, MidCity Place.

The design as proposed and assessed will achieve the required criteria provided the mitigation detailed in sections 5 of this report is implemented; the calculated rating levels are as follows:

Day:	39 dB $L_{Aeq,\,T}$ at 20m, MidCity Place.

This report concludes that the design criteria can be achieved.

ii) Document History

Issue	Date	Issue Details	Issued By	Checked By
1	15/05/2017	Initial Issue	RM	MB
2	17/05/2017	Minor Amendments	RM	MB
3	15/06/2018	Updated Plant Design	JN	MB
4	19/09/2018	Minor Amendments	RM	MB

1 Introduction

New mechanical plant is to be installed at 18-21 Hand Court, 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.

New mechanical plant will also be installed at a later date at 22-23 Hand court. The new plant will be the responsibility of the new tenants which will be required to undertake an assessment to ensure the noise criteria within this report is not exceeded.

The report details recommendations for necessary noise mitigation where necessary.

The guidance contained in this report is given on the basis that the plant may be consistently operating between 07:00 and 23:00.

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 receiver with direct line of sight to the plant area is 12m to the west of the site and approximately 20m from the proposed plant location. This is shown in both the site plan in Appendix A.

2.3 Local Noise Climate

The predominant local noise sources were road traffic noise.

2.4 Measurements

The noise monitoring took place between 11th and 13th April 2017. 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	4 m/s
Wind Direction	W
Cloud Cover	30%
Max. Temperature	17°C
Min. Temperature	5°C
Precipitation	None

2.5 Measurement Results

The measured statistical broad-band sound pressure levels are shown within Appendix B. 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*
MP1	49

* Day periods are defined as between 07:00 – 23:00.

3 Evaluation of Design Criteria

3.1 Residential Design Criterion

3.1.1 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.

3.1.2 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_{Amax}, 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.*"

3.1.3 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'.

3.1.4 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 lowest measured background noise level 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.

3.1.5 Recommended Residential Design Rating Level

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

Residential Design Rating Level
Representative $L_{A90,\ 15\ mins}$ - 10 dB

3.2 Emergency Plant

It would be inappropriate to impose the standard noise condition on emergency generators, although some restrictions should be imposed to prevent excessive use or nuisance.

The variation of condition is for the emergency generator plant to increase the existing background level by no more than 5dB (A) during brief testing periods and emergency use only. Although this level does not comply with the usual requirements it is nevertheless a high standard of noise reduction for such an item of plant.

The stand-by generators shall only be used during a mains power failure or other emergency. Test periods shall be restricted to one period of not more than 1 hour per month between the hours of 09.00 and 17.00 on Mondays to Fridays, excluding bank holidays.

3.2.1 Recommended Emergency Plant Design Rating Level

Based on the above, the recommended rating level at the nearest affected premises for the emergency generator shall therefore be:

Design Rating level
Representative $L_{A90,\ 15\ mins}$ + 5 dB

3.3 Design Rating Levels

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

Source	Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq,\ 16\ hr}$
Operational Plant	MidCity Place	20	39
Emergency Plant	MidCity Place	20	54

4 Review of Current Design

4.1 Current Design

The proposed plant shall be located on the roof at 5th floor level behind a 3m high louvered screen. It is assumed that the current proposal is for a standard weather louvre. The plant includes 8 x PUHZ-ZRP250YKA Condensers, 2 x PURY-P400YNW-A Retail Condensers, 1 x PUMY-P200YKM2 Reception Condenser, 1x Nuaire SQFTA41-1 Toilet Extract Fan. There is also space allocation for tenant plant, for the purposes of these calculations a typical unit specification of 4 x PUMY-P112YKM4 has been included.

The operational mechanical plant will operate between the hours of 07:00 – 23:00.

There is also an emergency generator and life safety extract fan to be located within the plant area. These will operate in emergency's only and for testing 1 hour per month between the hours of 09.00 and 17.00 on Mondays to Fridays, excluding bank holidays.

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 table below.

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

Source	Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq,\ 16\ hr}$	Predicted Level $L_{Aeq,T}$
Operational Plant	MidCity Place	20	39	45
Emergency Generator	MidCity Place	20	54	60

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

5 Noise Mitigation

As the operational plant has been assessed to be over the required criteria at the nearest noise sensitive receptor, the following mitigation is recommended to reduce noise emissions to acceptable levels.

5.1 Attenuators

It is recommended that an attenuator is included to the toilet extract fan exhaust, the recommended insertion loss performance based on the fan manufacturers ancillary product data is shown in the table below.

Table 9: Recommended attenuator performance, dB

Product	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Nuaire SQFS1S standard silencer	-	4	8	18	24	19	16	11

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.

5.2 Acoustic Louvre Screen

Additionally, it is recommended that the plant area screen is comprised of an acoustic louvre with the advised insertion loss performance provided in the following table.

Table 10: Recommended acoustic louvre performance, dB

Product	Octave Band Centre Frequency (Hz)								Rw
	63	125	250	500	1k	2k	4k	8k	
300mm acoustic louvre	6	6	9	13	21	20	16	13	18

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 this be implemented, 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, considering all the parameters of this situation. The problems of air flow, pressure drop etc, applicable to this equipment will all need to be considered. 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

5.3 Mitigated Results

The design rating levels to be adopted for this project, together with the predicted noise levels inclusive of the mitigation detailed in Sections 4 and 5, are set out in the table below.

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

Source	Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq,\ 16\ hr}$	Predicted Level $L_{Aeq,T}$
Operational Plant	MidCity Place	20	39	39
Emergency Generator	MidCity Place	20	54	54

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

6 Conclusion

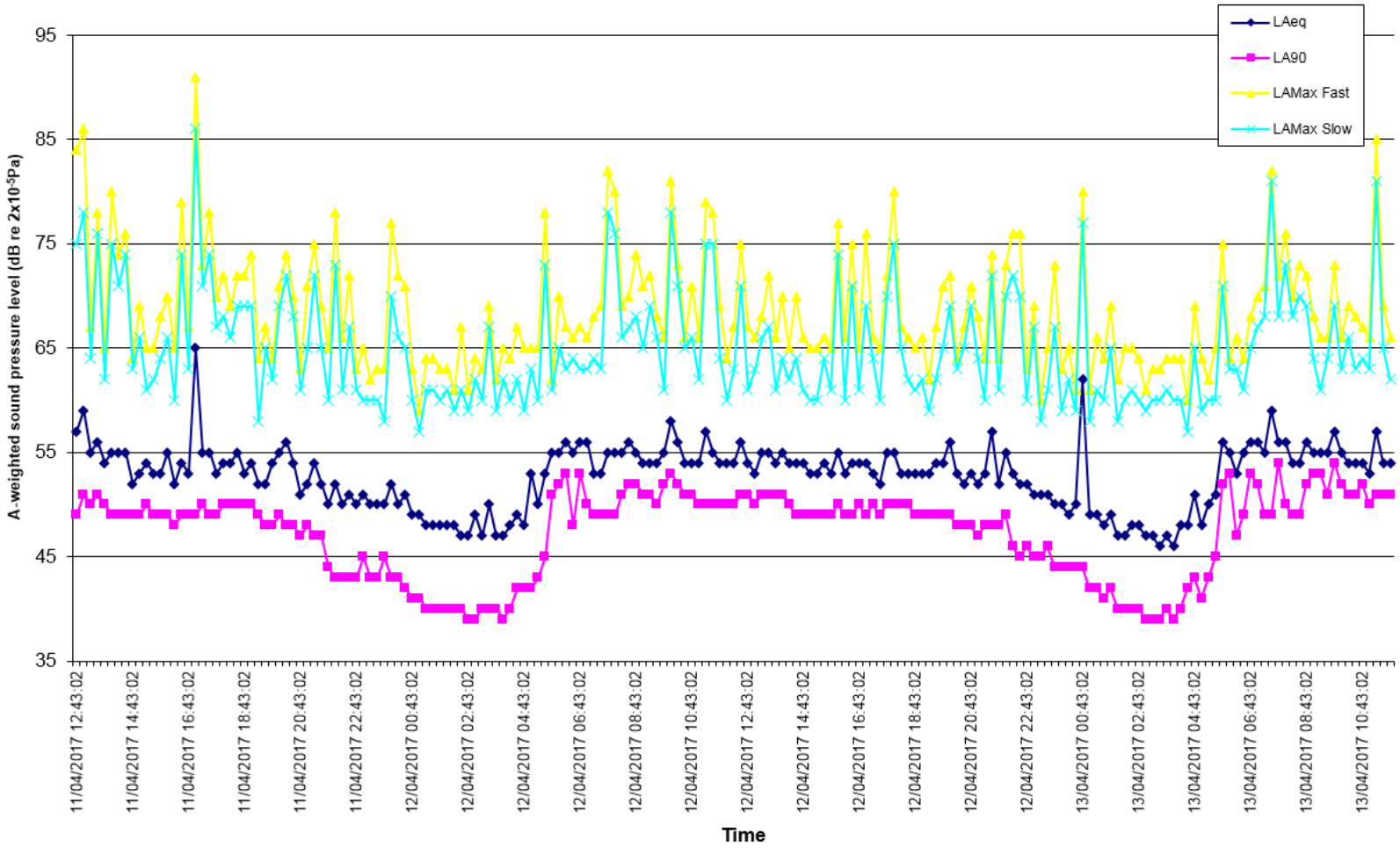
An environmental noise survey has been undertaken in order to establish the representative background sound levels local to the site generally in accordance with the method contained within BS4142: 2014.

Calculations have been carried out to determine the noise levels at the nearest receiver premises. The calculations show that with the implementation the noise mitigation measures detailed in section 5 of this report the design criteria will be met.

Appendix A: Site Plan

Approximate measurement position (Latitude & Longitude) 51°31'07.11" N 0°06'55.96" W.

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: 11207
- Svantek pre-amplifier SV12L S/N: 49860 with GRAS microphone capsule 40AE S/N: 215511

Calibration checks were made prior to and after completion of measurements using a Svantek SV30A calibrator, S/N: 10893 complying with Class 1 specification of BS EN 60942:2003, calibration level 94.0 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 data, dB

Plant	Distance (m)	Octave Band Centre Frequency (Hz)								L_A
		63	125	250	500	1k	2k	4k	8k	
Mitsubishi PUHZ-ZRP250YKA	L_p at 1m	66	63	61	60	58	53	48	42	62
Mitsubishi PURY-P400YNW-A	L_p at 1m	74	64	66	64	59	55	49	45	65
Mitsubishi PUMY-P200YKM2	L_p at 1m	63	61	61	58	57	52	49	41	61
Mitsubishi PUMY-P112YKM4	L_p at 1m	64	52	52	49	46	41	35	29	51
Nuaire SQFTA41-1 TEF Exhaust	L_w	85	92	71	64	69	70	65	59	78
Nuaire SQFTA41-1 TEF Breakout	L_w	82	85	67	58	55	56	49	35	70
Generator Limiting Level*	L_p at 1m	66	67	67	67	65	63	60	55	70
Life Safety Extract Fan Exhaust Limiting Level*	L_p at 1m	91	86	81	76	71	66	61	61	78
Life Safety Extract Fan Breakout Limiting Level*	L_p at 3m	66	61	56	51	46	41	36	36	53

* The sound pressure spectrum for this unit has been estimated based upon typical equipment spectral content.

Appendix D: Calculations

No mitigation, operational plant:

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	Attenuation 63	125	250	500	1k	2k	4k	8k	Reflections	dB	Attenuation 63	125	250	500	1k	2k	4k	8k
1	PUHZ-ZRP250YKA Condensers	1.00	66	63	61	60	58	53	48	42	62	70	23.0	-35	35	8	9	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
2	PURY-P400YNW-A Retail Condensers	1.00	74	64	66	64	59	55	49	45	65	73	20.5	-34	39	2	3	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
3	PUMY-P200YKM2 Reception Condenser	1.00	63	61	61	58	57	52	49	41	61	69	20.0	-34	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
4	PUMY-P112YKM4 Future Tenant Condensers	1.00	64	52	52	49	46	41	35	29	51	59	20.0	-34	25	4	6	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
5	TEF Exhaust		85	92	71	64	69	70	65	59	78	78	23.0	-35	43	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3								
6	TEF Breakout		82	85	67	58	55	56	49	35	70	70	23.0	-35	35	1	0	None	0	0	0	0	0	0	0	0	1	3								

Ref.	plant	Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	42	40	39	37	32	27	21	41
2	PURY-P400YNW-A Retail Condensers	48	38	40	38	33	29	23	19	39
3	PUMY-P200YKM2 Reception Condenser	34	32	32	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	41	29	29	26	23	18	12	6	28
5	TEF Exhaust	50	57	36	29	34	35	30	24	43
6	TEF Breakout	50	53	35	26	23	24	17	3	38
	Total	**55**	**58**	**44**	**42**	**40**	**38**	**32**	**27**	**47**

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
19.4	24.0	21.0	3.0	20.0	0.17	-6	-7	-9	-11	-14	-16	-19	-22
19.7	24.0	21.0	0.5	20.0	0.67	-9	-11	-14	-16	-19	-22	-24	-24
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24

Criteria NR	63	125	250	500	1k	2k	4k	8k	dB(A)
30	59	48	40	34	30	27	25	23	39

Barrier SRI		63	125	250	500	1k	2k	4k	8k	Rw
	Manual									0
	Weather Louvre	1	2	2	2	3	3	4	7	3

Ref.	Plant	Excess 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	-14	-6	0	5	7	5	2	-2	2
2	PURY-P400YNW-A Retail Condensers	-11	-10	0	4	3	2	-2	-4	0
3	PUMY-P200YKM2 Reception Condenser	-25	-16	-8	-5	-2	-4	-5	-11	-7
4	PUMY-P112YKM4 Future Tenant Condensers	-18	-19	-11	-8	-7	-9	-13	-17	-11
5	TEF Exhaust	-9	9	-4	-5	4	8	5	1	4
6	TEF Breakout	-9	5	-5	-8	-7	-3	-8	-20	-1
	Total	-5	10	5	8	10	11	8	4	8

Barrier Deration		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	6	6	8	10	11	13	15	15
	PURY-P400YNW-A Retail Condensers	9	10	12	14	16	19	20	17
	PUMY-P200YKM2 Reception Condenser	3	2	2	2	2	2	1	1
	PUMY-P112YKM4 Future Tenant Condensers	3	2	2	2	2	2	1	1
	TEF Exhaust	8	8	10	13	14	17	19	17
	TEF Breakout	8	8	10	13	14	17	19	17

Ref.	Plant	Mitigated Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	40	39	38	34	29	23	14	39
2	PURY-P400YNW-A Retail Condensers	48	37	38	35	30	26	19	12	36
3	PUMY-P200YKM2 Reception Condenser	37	34	34	31	30	25	21	13	34
4	PUMY-P112YKM4 Future Tenant Condensers	44	31	31	28	25	20	13	7	30
5	TEF Exhaust	50	55	34	28	31	32	26	17	41
6	TEF Breakout	50	51	33	25	20	21	13	-4	36
	Total	**55**	**57**	**44**	**41**	**38**	**35**	**29**	**20**	**45**

Net barrier loss		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	**0**	**-1**	**-1**	**-1**	**-3**	**-3**	**-4**	**-7**
	PURY-P400YNW-A Retail Condensers	**0**	**-1**	**-2**	**-2**	**-3**	**-3**	**-4**	**-7**
	PUMY-P200YKM2 Reception Condenser	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
	PUMY-P112YKM4 Future Tenant Condensers	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
	TEF Exhaust	**0**	**-1**	**-2**	**-1**	**-3**	**-3**	**-4**	**-7**
	TEF Breakout	**0**	**-1**	**-2**	**-1**	**-3**	**-3**	**-4**	**-7**

No mitigation, emergency plant:

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw)									Lw
			63	125	250	500	1k	2k	4k	8k	dB(A)	dB(A)
1	PUHZ-ZRP250YKA Condensers	1.00	66	63	61	60	58	53	48	42	62	70
2	PURY-P400YNW-A Retail Condensers	1.00	74	64	66	64	59	55	49	45	65	73
3	PUMY-P200YKM2 Reception Condenser	1.00	63	61	61	58	57	52	49	41	61	69
4	PUMY-P112YKM4 Future Tenant Condensers	1.00	64	52	52	49	46	41	35	29	51	59
5	TEF Exhaust		85	92	71	64	69	70	65	59	78	78
6	TEF Breakout		82	85	67	58	55	56	49	35	70	70
7	Emergency Generator	1.00	66	67	67	67	65	63	60	55	70	78
8	Life Safety Extract Fan Exhaust	1.00	91	86	81	76	71	66	61	61	78	86
9	Life Safety Extract Fan Breakout	3.00	66	61	56	51	46	41	36	36	53	71

Reciever Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality	63	125	250	500	1k	2k	4k	8k	Reflections	dB
23.0	-35	35	8	9	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0
20.5	-34	39	2	3	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0
20.0	-34	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0
20.0	-34	25	4	6	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0
23.0	-35	43	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3
23.0	-35	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3
26.0	-36	42	1	0	None	0	0	0	0	0	0	0	0	1	3
21.0	-34	52	1	0	None	0	0	0	0	0	0	0	0	1	3
20.0	-34	37	1	0	None	0	0	0	0	0	0	0	0	1	3

Additional Attenuation							
63	125	250	500	1k	2k	4k	8k

Ref.	plant	Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	42	40	39	37	32	27	21	41
2	PURY-P400YNW-A Retail Condensers	48	38	40	38	33	29	23	19	39
3	PUMY-P200YKM2 Reception Condenser	34	32	32	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	41	29	29	26	23	18	12	6	28
5	TEF Exhaust	50	57	36	29	34	35	30	24	43
6	TEF Breakout	47	50	32	23	20	21	14	0	35
7	Emergency Generator	41	42	42	42	40	38	35	30	45
8	Life Safety Extract Fan Exhaust	71	66	61	56	51	46	41	41	58
9	Life Safety Extract Fan Breakout	56	51	46	41	36	31	26	26	43
	Total	**74**	**69**	**64**	**59**	**54**	**50**	**45**	**44**	**62**

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
19.4	24.0	21.0	3.0	20.0	0.17	-6	-7	-9	-11	-14	-16	-19	-22
19.7	24.0	21.0	0.5	20.0	0.67	-9	-11	-14	-16	-19	-22	-24	-24
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
21.0	24.0	21.0	6.0	20.0	-0.05	-4	-4	-2	0	0	0	0	0
19.0	24.0	21.0	1.0	20.0	0.87	-10	-12	-15	-17	-20	-23	-24	-24
19.0	24.0			20.0	-29.63	0	0	0	0	0	0	0	0

Criteria									
NR	63	125	250	500	1k	2k	4k	8k	dB(A)
46	72	62	55	50	46	43	41	39	54

Barrier SRI		63	125	250	500	1k	2k	4k	8k	Rw
	Manual									0
	Weather Louvre	1	2	2	2	3	3	4	7	3

Ref.	Plant	Excess								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	-27	-20	-15	-11	-9	-11	-14	-19	-13
2	PURY-P400YNW-A Retail Condensers	-24	-24	-15	-12	-13	-14	-18	-21	-15
3	PUMY-P200YKM2 Reception Condenser	-38	-30	-23	-21	-18	-20	-21	-27	-22
4	PUMY-P112YKM4 Future Tenant Condensers	-31	-33	-26	-24	-23	-25	-29	-33	-26
5	TEF Exhaust	-22	-5	-19	-21	-12	-8	-11	-16	-11
6	TEF Breakout	-25	-12	-23	-27	-26	-22	-27	-40	-19
7	Emergency Generator	-31	-20	-13	-8	-6	-5	-6	-10	-9
8	Life Safety Extract Fan Exhaust	-1	4	6	6	5	2	0	1	4
9	Life Safety Extract Fan Breakout	-16	-11	-9	-9	-10	-13	-16	-14	-11
	Total	2	7	9	9	8	7	4	5	8

Barrier Deration		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	6	6	8	10	11	13	15	15
	PURY-P400YNW-A Retail Condensers	9	10	12	14	16	19	20	17
	PUMY-P200YKM2 Reception Condenser	3	2	2	2	2	2	1	1
	PUMY-P112YKM4 Future Tenant Condensers	3	2	2	2	2	2	1	1
	TEF Exhaust	8	8	10	13	14	17	19	17
	TEF Breakout	8	8	10	13	14	17	19	17
	Emergency Generator	5	4	3	2	2	2	1	1
	Life Safety Extract Fan Exhaust	9	10	13	15	17	20	20	17
	Life Safety Extract Fan Breakout	3	2	2	2	2	2	1	1

Ref.	Plant	Mitigated Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	40	39	38	34	29	23	14	39
2	PURY-P400YNW-A Retail Condensers	48	37	38	35	30	26	19	12	36
3	PUMY-P200YKM2 Reception Condenser	37	34	34	31	30	25	21	13	34
4	PUMY-P112YKM4 Future Tenant Condensers	44	31	31	28	25	20	13	7	30
5	TEF Exhaust	50	55	34	28	31	32	26	17	41
6	TEF Breakout	47	48	30	22	17	18	10	-7	33
7	Emergency Generator	42	42	43	44	42	40	36	31	47
8	Life Safety Extract Fan Exhaust	70	64	59	53	47	42	37	34	56
9	Life Safety Extract Fan Breakout	59	53	48	43	38	33	27	27	45
	Total	**73**	**68**	**62**	**57**	**52**	**48**	**43**	**39**	**60**

Net barrier loss		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	**0**	**-1**	**-1**	**-1**	**-3**	**-3**	**-4**	**-7**
	PURY-P400YNW-A Retail Condensers	**0**	**-1**	**-2**	**-2**	**-3**	**-3**	**-4**	**-7**
	PUMY-P200YKM2 Reception Condenser	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
	PUMY-P112YKM4 Future Tenant Condensers	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**
	TEF Exhaust	**0**	**-1**	**-2**	**-1**	**-3**	**-3**	**-4**	**-7**
	TEF Breakout	**0**	**-1**	**-2**	**-1**	**-3**	**-3**	**-4**	**-7**
	Emergency Generator	**1**	**0**	**1**	**2**	**2**	**2**	**1**	**1**
	Life Safety Extract Fan Exhaust	**-1**	**-2**	**-2**	**-2**	**-3**	**-3**	**-4**	**-7**
	Life Safety Extract Fan Breakout	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**

Including mitigation, operational plant:

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	63	125	250	500	1k	2k	4k	8k	Reflections	dB	Attenuation 63	125	250	500	1k	2k	4k	8k
1	PUHZ-ZRP250YKA Condensers	1.00	66	63	61	60	58	53	48	42	62	70	23.0	-35	35	8	9	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
2	PURY-P400YNW-A Retail Condensers	1.00	74	64	66	64	59	55	49	45	65	73	20.5	-34	39	2	3	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
3	PUMY-P200YKM2 Reception Condenser	1.00	63	61	61	58	57	52	49	41	61	69	20.0	-34	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
4	PUMY-P112YKM4 Future Tenant Condensers	1.00	64	52	52	49	46	41	35	29	51	59	20.0	-34	25	4	6	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
5	TEF Exhaust		85	92	71	64	69	70	65	59	78	78	23.0	-35	43	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3		4	8	12	24	19	16	11
6	TEF Breakout		82	85	67	58	55	56	49	35	70	70	23.0	-35	35	1	0	None	0	0	0	0	0	0	0	0	1	3								

Ref.	plant	Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	42	40	39	37	32	27	21	41
2	PURY-P400YNW-A Retail Condensers	48	38	40	38	33	29	23	19	39
3	PUMY-P200YKM2 Reception Condenser	34	32	32	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	41	29	29	26	23	18	12	6	28
5	TEF Exhaust	50	57	36	29	34	35	30	24	43
6	TEF Breakout	50	53	35	26	23	24	17	3	38
	Total	**55**	**58**	**44**	**42**	**40**	**38**	**32**	**27**	**47**

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
19.4	24.0	21.0	3.0	20.0	0.17	-6	-7	-9	-11	-14	-16	-19	-22
19.7	24.0	21.0	0.5	20.0	0.67	-9	-11	-14	-16	-19	-22	-24	-24
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24

Criteria NR	63	125	250	500	1k	2k	4k	8k	dB(A)
30	59	48	40	34	30	27	25	23	39

Barrier SRI		63	125	250	500	1k	2k	4k	8k	Rw
	Manual									0
	SS300	6	6	9	13	21	20	16	13	18

Ref.	Plant	Excess 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	-14	-6	0	5	7	5	2	-2	2
2	PURY-P400YNW-A Retail Condensers	-11	-10	0	4	3	2	-2	-4	0
3	PUMY-P200YKM2 Reception Condenser	-25	-16	-8	-5	-2	-4	-5	-11	-7
4	PUMY-P112YKM4 Future Tenant Condensers	-18	-19	-11	-8	-7	-9	-13	-17	-11
5	TEF Exhaust	-9	9	-4	-5	4	8	5	1	4
6	TEF Breakout	-9	5	-5	-8	-7	-3	-8	-20	-1
	Total	-5	10	5	8	10	11	8	4	8

Barrier Deration		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	3	4	3	2	1	2	5	10
	PURY-P400YNW-A Retail Condensers	5	6	6	5	2	4	9	11
	PUMY-P200YKM2 Reception Condenser	1	1	1	0	0	0	0	0
	PUMY-P112YKM4 Future Tenant Condensers	1	1	1	0	0	0	0	0
	TEF Exhaust	4	5	5	4	1	3	8	11
	TEF Breakout	4	5	5	4	1	3	8	11

Ref.	Plant	Mitigated Receiver Lp 63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	42	38	34	30	24	18	13	9	31
2	PURY-P400YNW-A Retail Condensers	44	33	32	26	16	11	8	6	28
3	PUMY-P200YKM2 Reception Condenser	35	33	33	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	42	30	30	26	23	18	12	6	28
5	TEF Exhaust	46	48	21	7	-6	-1	-1	0	32
6	TEF Breakout	46	48	28	16	7	7	2	-10	33
	Total	**51**	**52**	**39**	**34**	**31**	**25**	**22**	**15**	**39**

Net barrier loss		63	125	250	500	1k	2k	4k	8k
	PUHZ-ZRP250YKA Condensers	**-3**	**-3**	**-6**	**-9**	**-13**	**-14**	**-14**	**-12**
	PURY-P400YNW-A Retail Condensers	**-4**	**-5**	**-8**	**-11**	**-17**	**-18**	**-15**	**-13**
	PUMY-P200YKM2 Reception Condenser	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
	PUMY-P112YKM4 Future Tenant Condensers	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
	TEF Exhaust	**-4**	**-4**	**-7**	**-10**	**-16**	**-17**	**-15**	**-13**
	TEF Breakout	**-4**	**-4**	**-7**	**-10**	**-16**	**-17**	**-15**	**-13**

Including mitigation, emergency plant:

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw)									Lw	Reciever Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality	63	125	250	500	1k	2k	4k	8k	Reflections	dB	Additional Attenuation								
			63	125	250	500	1k	2k	4k	8k	dB(A)	dB(A)																	63	125	250	500	1k	2k	4k	8k
1	PUHZ-ZRP250YKA Condensers	1.00	66	63	61	60	58	53	48	42	62	70	23.0	-35	35	8	9	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
2	PURY-P400YNW-A Retail Condensers	1.00	74	64	66	64	59	55	49	45	65	73	20.5	-34	39	2	3	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
3	PUMY-P200YKM2 Reception Condenser	1.00	63	61	61	58	57	52	49	41	61	69	20.0	-34	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
4	PUMY-P112YKM4 Future Tenant Condensers	1.00	64	52	52	49	46	41	35	29	51	59	20.0	-34	25	4	6	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	0	0								
5	TEF Exhaust		85	92	71	64	69	70	65	59	78	78	23.0	-35	43	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3		4	8	12	24	19	16	11
6	TEF Breakout		82	85	67	58	55	56	49	35	70	70	23.0	-35	35	1	0	45(-3dB)	-3	-3	-3	-3	-3	-3	-3	-3	1	3								
7	Emergency Generator	1.00	66	67	67	67	65	63	60	55	70	78	26.0	-36	42	1	0	None	0	0	0	0	0	0	0	0	1	3								
8	Life Safety Extract Fan Exhaust	1.00	91	86	81	76	71	66	61	61	78	86	21.0	-34	52	1	0	None	0	0	0	0	0	0	0	0	1	3								
9	Life Safety Extract Fan Breakout	3.00	66	61	56	51	46	41	36	36	53	71	20.0	-34	37	1	0	None	0	0	0	0	0	0	0	0	1	3								

Ref.	plant	Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	45	42	40	39	37	32	27	21	41
2	PURY-P400YNW-A Retail Condensers	48	38	40	38	33	29	23	19	39
3	PUMY-P200YKM2 Reception Condenser	34	32	32	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	41	29	29	26	23	18	12	6	28
5	TEF Exhaust	50	57	36	29	34	35	30	24	43
6	TEF Breakout	47	50	32	23	20	21	14	0	35
7	Emergency Generator	41	42	42	42	40	38	35	30	45
8	Life Safety Extract Fan Exhaust	71	66	61	56	51	46	41	41	58
9	Life Safety Extract Fan Breakout	56	51	46	41	36	31	26	26	43
	Total	**74**	**69**	**64**	**59**	**54**	**50**	**45**	**44**	**62**

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
19.4	24.0	21.0	3.0	20.0	0.17	-6	-7	-9	-11	-14	-16	-19	-22
19.7	24.0	21.0	0.5	20.0	0.67	-9	-11	-14	-16	-19	-22	-24	-24
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
20.7	24.0	0.0		20.0	-31.61	0	0	0	0	0	0	0	0
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
18.7	24.0	21.0	3.0	20.0	0.40	-8	-9	-12	-14	-17	-20	-23	-24
21.0	24.0	21.0	6.0	20.0	-0.05	-4	-4	-2	0	0	0	0	0
19.0	24.0	21.0	1.0	20.0	0.87	-10	-12	-15	-17	-20	-23	-24	-24
19.0	24.0			20.0	-29.63	0	0	0	0	0	0	0	0

Criteria									
NR	63	125	250	500	1k	2k	4k	8k	dB(A)
46	72	62	55	50	46	43	41	39	54

Barrier SRI		63	125	250	500	1k	2k	4k	8k	Rw
	Manual									0
	SS300	6	6	9	13	21	20	16	13	18

Ref.	Plant	Excess								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	-27	-20	-15	-11	-9	-11	-14	-19	-13
2	PURY-P400YNW-A Retail Condensers	-24	-24	-15	-12	-13	-14	-18	-21	-15
3	PUMY-P200YKM2 Reception Condenser	-38	-30	-23	-21	-18	-20	-21	-27	-22
4	PUMY-P112YKM4 Future Tenant Condensers	-31	-33	-26	-24	-23	-25	-29	-33	-26
5	TEF Exhaust	-22	-5	-19	-21	-12	-8	-11	-16	-11
6	TEF Breakout	-25	-12	-23	-27	-26	-22	-27	-40	-19
7	Emergency Generator	-31	-20	-13	-8	-6	-5	-6	-10	-9
8	Life Safety Extract Fan Exhaust	-1	4	6	6	5	2	0	1	4
9	Life Safety Extract Fan Breakout	-16	-11	-9	-9	-10	-13	-16	-14	-11
	Total	2	7	9	9	8	7	4	5	8

Barrier Deration									
PUHZ-ZRP250YKA Condensers	3	4	3	2	1	2	5	10
PURY-P400YNW-A Retail Condensers	5	6	6	5	2	4	9	11
PUMY-P200YKM2 Reception Condenser	1	1	1	0	0	0	0	0
PUMY-P112YKM4 Future Tenant Condensers	1	1	1	0	0	0	0	0
TEF Exhaust	4	5	5	4	1	3	8	11
TEF Breakout	4	5	5	4	1	3	8	11
Emergency Generator	2	2	1	0	0	0	0	0
Life Safety Extract Fan Exhaust	5	7	7	6	3	5	9	11
Life Safety Extract Fan Breakout	1	1	1	0	0	0	0	0

Ref.	Plant	Mitigated Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	PUHZ-ZRP250YKA Condensers	42	38	34	30	24	18	13	9	31
2	PURY-P400YNW-A Retail Condensers	44	33	32	26	16	11	8	6	28
3	PUMY-P200YKM2 Reception Condenser	35	33	33	29	28	23	20	12	32
4	PUMY-P112YKM4 Future Tenant Condensers	42	30	30	26	23	18	12	6	28
5	TEF Exhaust	46	48	21	7	-6	-1	-1	0	32
6	TEF Breakout	43	45	25	13	4	4	-1	-13	30
7	Emergency Generator	39	40	41	42	40	38	35	30	45
8	Life Safety Extract Fan Exhaust	66	61	53	44	33	27	26	28	49
9	Life Safety Extract Fan Breakout	57	52	47	41	36	31	26	26	43
	Total	**69**	**64**	**57**	**50**	**45**	**42**	**39**	**36**	**54**

Net barrier loss									
PUHZ-ZRP250YKA Condensers	**-3**	**-3**	**-6**	**-9**	**-13**	**-14**	**-14**	**-12**
PURY-P400YNW-A Retail Condensers	**-4**	**-5**	**-8**	**-11**	**-17**	**-18**	**-15**	**-13**
PUMY-P200YKM2 Reception Condenser	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
PUMY-P112YKM4 Future Tenant Condensers	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
TEF Exhaust	**-4**	**-4**	**-7**	**-10**	**-16**	**-17**	**-15**	**-13**
TEF Breakout	**-4**	**-4**	**-7**	**-10**	**-16**	**-17**	**-15**	**-13**
Emergency Generator	**-2**	**-2**	**-1**	**0**	**0**	**0**	**0**	**0**
Life Safety Extract Fan Exhaust	**-5**	**-5**	**-8**	**-11**	**-17**	**-18**	**-15**	**-13**
Life Safety Extract Fan Breakout	**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.