

Acoustic Consultancy Report

98141/3/2/6

External Plant Assessment Heat Pump Installation

Report Prepared For

Vital Energi
Manchester Energy Centre
22 July 2021

Report Author

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i) Executive Summary

New mechanical plant is to be installed at The Christie NHS Foundation Trust in Manchester.

LCP has been commissioned by Vital Energi 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:	44 dB $L_{Aeq, T}$ at 49m, Nearest residential receiver to the north of site (Tatton Grove);
Night:	42 dB $L_{Aeq, T}$ at 49m, Nearest residential receiver to the north of site (Tatton Grove);
Hospital Building:	50 dB $L_{Aeq, T}$ at 7m, Hospital office window towards the east of site;
Hospital Building:	50 dB $L_{Aeq, T}$ at 4m, Hospital office window towards the south of site.

The design as proposed and assessed will achieve the required criteria the calculated rating levels are as follows:

Day:	35 dB $L_{Aeq, T}$ at 49m, Nearest residential receiver to the north of site (Tatton Grove);
Night:	35 dB $L_{Aeq, T}$ at 49m, Nearest residential receiver to the north of site (Tatton Grove);
Hospital Building:	50 dB $L_{Aeq, T}$ at 7m, Hospital office window towards the east of site;
Hospital Building:	50 dB $L_{Aeq, T}$ at 4m, Hospital office window towards the south of site.

This report concludes that the design criteria will be achieved.

ii) Document History

Issue	Date	Issue Details	Issued By	Checked By
1	22 nd July 2021	Initial Issue	RM	VB

1 Introduction

New mechanical plant is to be installed at The Christie NHS Foundation Trust in Manchester.

LCP has been commissioned by Vital Energi 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 in this report is on the basis that the mechanical plant will be consistently operating over a 24 hour period.

2 Survey

2.1 Site Description

The site layout together with the measurement positions are 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 49m to the North of the site. The nearest hospital building receivers are offices which are located 7m towards the east and 4m towards the south of the site. This is shown in the site plan in Appendix A.

2.3 Local Noise Climate

The predominant local noise sources were delivery vehicle activity and existing mechanical plant noise from the site.

2.4 Measurements

The noise monitoring took place between 9th – 10th January 2020. 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	East
Cloud Cover	75%
Max. Temperature	7°C
Min. Temperature	2°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 2×10^{-5} Pa

Measurement Position	L _{A90} , 15 mins Day*	L _{A90} , 15 mins Night*
MP1	49	47

* Day and night periods are defined as between 07:00 - 23:00 and 23:00 - 07:00 respectively.

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 2×10^{-5} Pa

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

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 noisier environments.”

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

3.1.4 Local Authority Requirements

Manchester Noise and Planning Guidance December 2015 section 3.6.1.5 states the following:

‘The development should be designed so as to achieve a rating level of 5dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location’.

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 $L_{A90, 15 \text{ mins}}$ – 5 dB

3.2 Health Technical Memorandum 08-01:2013

The criteria for external noise levels is shown in the table below.

Using the general guidance from BS8233 and Guidelines for Community Noise, 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 1 of HTM08-1: 2013 in order to obtain acceptable external noise levels.

Table 7: External ambient noise levels for Hospitals, based on HTM08-01, dB re 2x10⁻⁵ Pa

Room Type	Example	External Ambient Noise Criteria
Ward - single person	Single-bed ward, single-bed recovery areas and on-call room, relatives’ overnight stay	50 $L_{Aeq, 1hr, \text{daytime}}$ 45 $L_{Aeq, 1hr, \text{night}}$ 55 $L_{Amax, f, \text{night}}$
Ward - multi-bed	Multi-bed wards, recovery areas	55 $L_{Aeq, 1hr, \text{daytime}}$ 45 $L_{Aeq, 1hr, \text{night}}$ 55 $L_{Amax, f, \text{night}}$
Small office-type spaces	Private offices, small treatment rooms, interview rooms, consulting rooms	50 $L_{Aeq, 1hr}$
Circulation spaces	Corridors, hospital street, atria	55 $L_{Aeq, 1hr}$
Open clinical areas	A&E	55 $L_{Aeq, 1hr}$

3.3 Recommended Design Rating Levels

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

Table 8: Design rating levels, dB re 2×10^{-5} Pa

Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq, 16 \text{ hr}}$	Design Level (Night) $L_{Aeq, 8 \text{ hr}}$
Nearest residential receiver to the north of site (Tatton Grove)	41	44	42
Hospital office window towards the east of site	7	50	50
Hospital office window towards the south of site	4	50	50

4 Review of Current Design

4.1 Current Design

The proposed plant will be installed on an existing flat roof on the second floor and will be surrounded by a 0.8m tall brick parapet. The proposed plant will consist of 2x Vertical Airflow Collectors, 2x ASHP Compressors and 1x WSHP. Plant locations are shown in Appendix D.

The WSHP unit will be fully enclosed within a GRP enclosure which will be naturally ventilated through a weather louvre.

All proposed mechanical plant will have the capability to operate continuously over a 24 hour period.

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 9: Design and predicted rating levels, dB re 2×10^{-5} Pa

Receiver Premises	Approximate Distance (m)	Design Level (Day) $L_{Aeq, 16 \text{ hr}}$	Design Level (Night) $L_{Aeq, 8 \text{ hr}}$	Predicted Level $L_{Aeq,T}$
Nearest residential receiver to the north of site (Tatton Grove)	49	44	42	35
Hospital office window towards the east of site	7	50	50	50
Hospital office window towards the south of site	4	50	50	50

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

Calculations are shown within Appendix E.

5 Conclusion

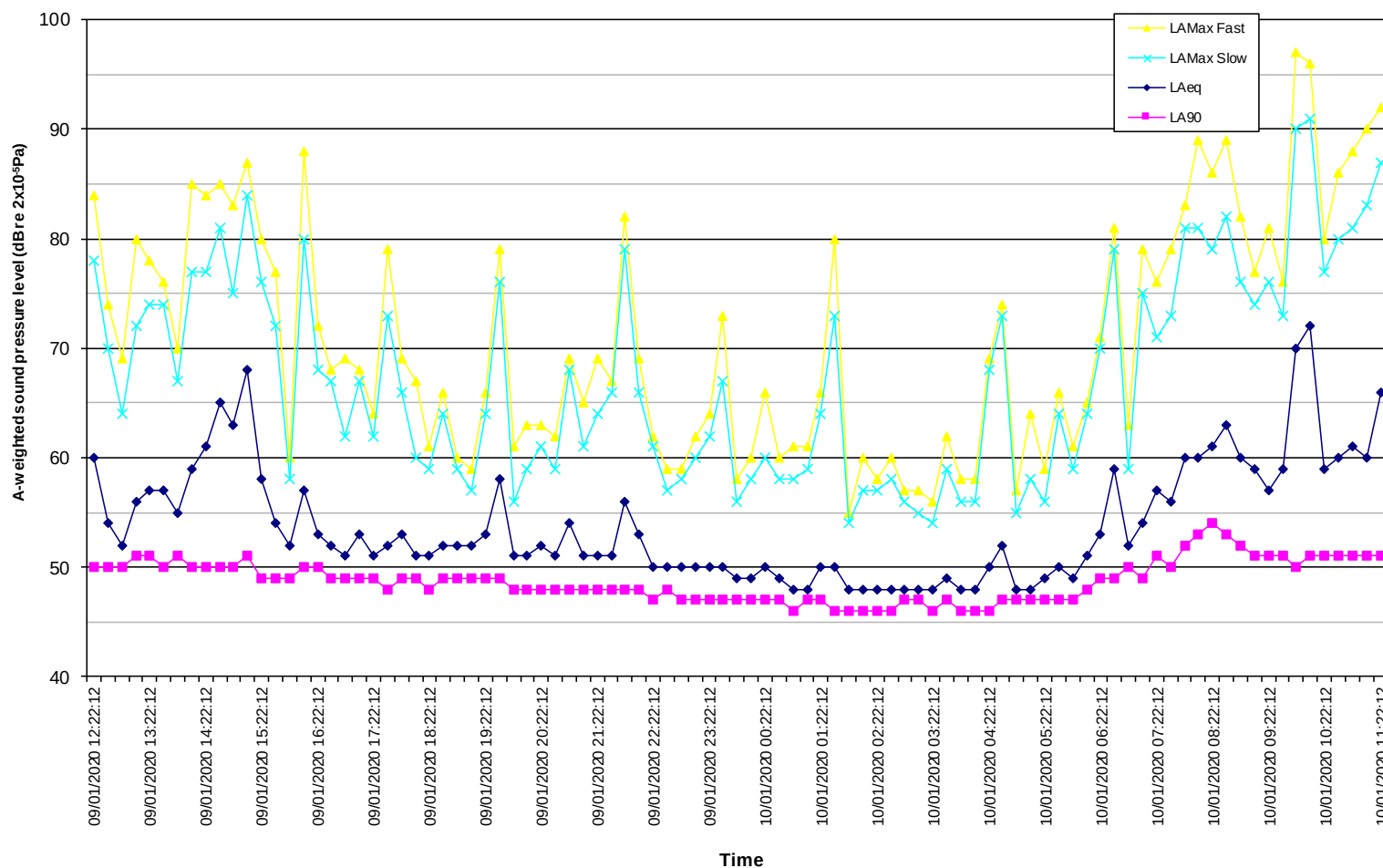
An environmental noise survey has been undertaken in order to establish the representative background sound levels local to the site generally in accordance with the method contained within BS4142: 2014.

Calculations have been carried out to determine the noise levels at the nearest receiver premises. The calculations show that the design criteria will be met.

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: 11205
- Svantek pre-amplifier SV12L S/N: 13245 with GRAS microphone capsule 40AE S/N: 75181

Calibration checks were made prior to and after completion of measurements using a Svantek SV30A calibrator, S/N: 10890 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

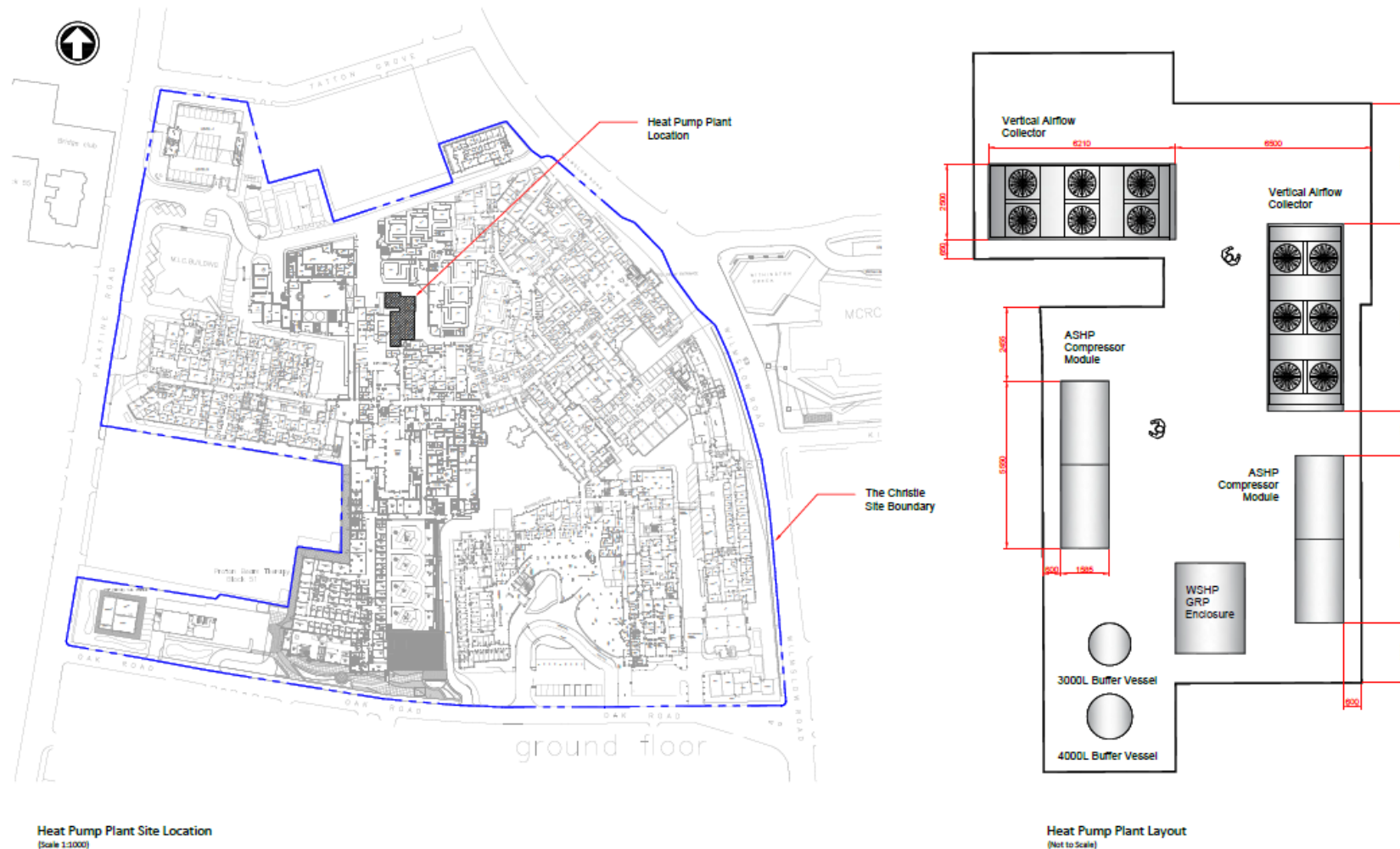
Plant noise data used in the preceding assessment follow.

Table 10: Manufacturer's plant sound pressure data, dB re 2×10^{-5} Pa

Plant	Distance (m)	Octave Band Centre Frequency (Hz)								L _{PA}
		63	125	250	500	1k	2k	4k	8k	
Vertical Airflow Collector	10	42	32	30	33	29	25	20	6	34
ASHP Compressor	10	42	32	30	33	29	25	20	6	34
WSHP*	1	52	53	55	55	58	55	51	45	62

* The sound pressure spectrum for this unit has been estimated based upon the manufacturer's single figure broadband value.

Appendix D: Proposed Heat Pump Installation



Appendix E: Calculations

Residential:

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw)								Lw	Receiver Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality	63	125	250	500	1k	2k	4k	8k	Reflections	dB	Façade correction	dB	Additional Attenuation								
			63	125	250	500	1k	2k	4k	8k																				dB(A)	63	125	250	500	1k	2k	4k	8k
1	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	49.0	-42	20	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
2	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	54.0	-43	19	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
3	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	57.0	-43	19	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
4	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	60.0	-44	18	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
5	WSHP	1.00	52	53	55	55	58	55	51	45	62	70	62.0	-44	26	1	0	None	0	0	0	0	0	0	0	0	0	0	Yes	3	1	2	2	2	3	3	4	7

Ref.	plant	Receiver Lp								dB(A)
		63	125	250	500	1k	2k	4k	8k	
1	Vertical Airflow Collector	34	24	22	25	21	17	12	-2	26
2	Vertical Airflow Collector	33	23	21	24	20	16	11	-3	25
3	ASHP Compressor	33	23	21	24	20	16	11	-3	25
4	ASHP Compressor	32	22	20	23	19	15	10	-4	24
5	WSHP	19	20	22	22	25	22	18	12	29
Total		42	33	31	34	32	28	24	16	36

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
5.7	5.0	4.8	2.5	46.5	-0.15	-3	0	0	0	0	0	0	0
5.7	5.0	4.8	4.0	50.0	-0.10	-4	-2	0	0	0	0	0	0
6.7	5.0	4.8	2.5	54.5	-0.60	0	0	0	0	0	0	0	0
6.7	5.0	4.8	11.7	48.3	-0.13	-3	-1	0	0	0	0	0	0
6.0	5.0	4.8	13.0	49.0	-0.05	-4	-4	-2	0	0	0	0	0

Barrier SRI																				
						63	125	250	500	1k	2k	4k	8k	Rw						
						Manual						0								
						Typical 110mm brick wall						33	37	34	40	48	56	61	61	45

Ref.	Plant	Excess								dB(A)
		63	125	250	500	1k	2k	4k	8k	
1	Vertical Airflow Collector	-27	-27	-20	-12	-12	-13	-16	-28	-16
2	Vertical Airflow Collector	-28	-27	-21	-13	-13	-14	-16	-29	-17
3	ASHP Compressor	-29	-28	-22	-13	-13	-14	-17	-29	-17
4	ASHP Compressor	-29	-28	-22	-14	-14	-15	-17	-30	-18
5	WSHP	-42	-31	-21	-15	-8	-8	-10	-14	-13
Total		-19	-18	-11	-3	-1	-2	-4	-10	-6

Ref.	Plant	Mitigated Receiver Lp								dB(A)
		63	125	250	500	1k	2k	4k	8k	
1	Vertical Airflow Collector	31	24	22	25	21	17	12	-2	26
2	Vertical Airflow Collector	30	21	21	24	20	16	11	-3	25
3	ASHP Compressor	33	23	21	24	20	16	11	-3	25
4	ASHP Compressor	29	22	20	23	19	15	10	-4	24
5	WSHP	14	15	18	20	22	19	14	5	26
Total		40	32	31	34	31	27	22	10	35

Net barrier loss													
						63	125	250	500	1k	2k	4k	8k
						Vertical Airflow Collector	-3	0	0	0	0	0	0
						Vertical Airflow Collector	-4	-2	0	0	0	0	0
						ASHP Compressor	0	0	0	0	0	0	0
						ASHP Compressor	-3	-1	0	0	0	0	0
						WSHP	-4	-4	-2	0	0	0	0

Hospital Office Window East:

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw)										Lw dB(A)	Receiver Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality	63	125	250	500	1k	2k	4k	8k	Reflections	dB	Façade correction	dB	Additional Attenuation							
			63	125	250	500	1k	2k	4k	8k	63	125																				250	500	1k	2k	4k	8k	63	125
1	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	19.0	-34	28	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3									
2	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	12.0	-30	32	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3									
3	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	7.0	-25	37	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3									
4	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	15.0	-32	30	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3									
5	WSHP	1.00	52	53	55	55	58	55	51	45	62	70	11.0	-29	41	1	0	None	0	0	0	0	0	0	0	0	0	0	Yes	3	1	2	2	2	3	3	4	7	

Ref.	plant	Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	42	32	30	33	29	25	20	6	34
2	Vertical Airflow Collector	46	36	34	37	33	29	24	10	38
3	ASHP Compressor	51	41	39	42	38	34	29	15	43
4	ASHP Compressor	44	34	32	35	31	27	22	8	36
5	WSHP	34	35	37	37	40	37	33	27	44
Total		56	47	46	48	46	43	38	31	51

Ref.	plant	Criteria									
		NR	63	125	250	500	1k	2k	4k	8k	dB(A)
		42	69	59	51	46	42	39	37	35	50

Ref.	Plant	Excess								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	-26	-26	-21	-12	-13	-14	-17	-29	-16
2	Vertical Airflow Collector	-22	-22	-17	-8	-9	-10	-13	-25	-12
3	ASHP Compressor	-18	-17	-12	-4	-4	-5	-8	-20	-7
4	ASHP Compressor	-24	-24	-19	-10	-11	-12	-14	-27	-14
5	WSHP	-35	-23	-14	-9	-2	-2	-4	-8	-7
Total		-12	-12	-5	2	4	4	1	-5	0

Ref.	Plant	Mitigated Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	38	29	29	33	29	25	20	6	34
2	Vertical Airflow Collector	46	36	34	37	33	29	24	10	38
3	ASHP Compressor	51	41	39	42	38	34	29	15	43
4	ASHP Compressor	41	32	32	35	31	27	22	8	36
5	WSHP	30	31	35	35	37	34	29	20	41
Total		56	46	45	48	45	41	36	25	50

Barrier SRI										63	125	250	500	1k	2k	4k	8k	Rw	
		Manual																	0
		Typical 110mm brick wall								33	37	34	40	48	56	61	61	45	

Barrier Deration				Vertical Airflow Collector		0	0	0	0	0	0	0	0	0	0	0	0	0
				Vertical Airflow Collector <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td></td></td>		0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0</td></td></td></td></td>	0 <td>0<td>0<td>0<td>0</td></td></td></td>	0 <td>0<td>0<td>0</td></td></td>	0 <td>0<td>0</td></td>	0 <td>0</td>	0
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Net barrier loss				Vertical Airflow Collector		-4	-4	-2	0	0	0	0	0	0	0	0	0	0
				Vertical Airflow Collector <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td></td></td>		0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0<td>0</td></td></td></td></td></td>	0 <td>0<td>0<td>0<td>0<td>0</td></td></td></td></td>	0 <td>0<td>0<td>0<td>0</td></td></td></td>	0 <td>0<td>0<td>0</td></td></td>	0 <td>0<td>0</td></td>	0 <td>0</td>	0
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Hospital Office Window South:

Ref.	plant	Ref.dist.	Sound Level (Lp/Lw)								Lw dB(A)	Receiever Distance (m)	dB(A)	Lp	No. off	dB	Angular Directionality	63	125	250	500	1k	2k	4k	8k	Reflections	dB	Façade correction	dB	Additional Attenuation								
			63	125	250	500	1k	2k	4k	8k																				dB(A)	63	125	250	500	1k	2k	4k	8k
1	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	19.0	-34	28	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
2	Vertical Airflow Collector	10.00	42	32	30	33	29	25	20	6	34	62	11.0	-29	33	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
3	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	4.0	-20	42	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
4	ASHP Compressor	10.00	42	32	30	33	29	25	20	6	34	62	12.0	-30	32	1	0	None	0	0	0	0	0	0	0	0	1	3	Yes	3								
5	WSHP	1.00	52	53	55	55	58	55	51	45	62	70	6.0	-24	46	1	0	None	0	0	0	0	0	0	0	0	0	0	Yes	3	1	2	2	2	3	3	4	7

Ref.	plant	Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	42	32	30	33	29	25	20	6	34
2	Vertical Airflow Collector	47	37	35	38	34	30	25	11	39
3	ASHP Compressor	55	45	43	46	42	38	33	19	47
4	ASHP Compressor	46	36	34	37	33	29	24	10	38
5	WSHP	39	40	42	42	45	42	38	32	49
	Total	57	48	47	49	48	44	40	33	52

Ref.	plant	Criteria									
		NR	63	125	250	500	1k	2k	4k	8k	dB(A)
		42	69	59	51	46	42	39	37	35	50

Ref.	Plant	Excess								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	-27	-27	-21	-13	-13	-14	-17	-29	-16
2	Vertical Airflow Collector	-22	-22	-16	-8	-8	-9	-12	-25	-12
3	ASHP Compressor	-13	-13	-8	1	0	-1	-3	-16	-3
4	ASHP Compressor	-23	-23	-17	-9	-9	-10	-13	-25	-12
5	WSHP	-29	-18	-9	-3	3	3	1	-3	-1
	Total	-12	-11	-4	3	6	5	3	-3	2

Ref.	Plant	Mitigated Receiver Lp								
		63	125	250	500	1k	2k	4k	8k	dB(A)
1	Vertical Airflow Collector	37	28	26	30	29	25	20	6	33
2	Vertical Airflow Collector	42	33	32	37	34	30	25	11	38
3	ASHP Compressor	55	45	43	46	42	38	33	19	47
4	ASHP Compressor	42	34	34	37	33	29	24	10	38
5	WSHP	35	36	40	40	42	39	34	25	46
	Total	56	46	46	48	46	43	38	27	50

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
	5.7	5.0	4.8	15.0	4.0	-0.02	-5	-4	-4	-3	0	0	0	0
	5.7	5.0	4.8	9.0	2.0	-0.03	-4	-4	-3	0	0	0	0	0
	6.7	5.0	4.8	2.0	2.0	-0.42	0	0	0	0	0	0	0	0
	6.7	5.0	4.8	8.0	4.0	-0.11	-3	-2	0	0	0	0	0	0
	6.0	5.0	4.8	5.0	1.0	-0.08	-4	-3	0	0	0	0	0	0

Barrier SRI											63	125	250	500	1k	2k	4k	8k	Rw	
											Manual									45
											Typical 110mm brick wall	33	37	34	40	48	56	61	61	

Barrier Deration		Vertical Airflow Collector	Vertical Airflow Collector	ASHP Compressor	ASHP Compressor	WSHP													
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Net barrier loss		Vertical Airflow Collector	Vertical Airflow Collector	ASHP Compressor	ASHP Compressor	WSHP													
		-5	-4	-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		-4	-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		-3	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		-4	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix F: 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 $\neq$ 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.

LA90, 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.

LAeq, T

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

LAmax

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

LAmin

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 2×10^{-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.