AŁN
acoustic design

ATG The Ambassadors Theatre

Plant Noise Assessment

Report Reference: J0463_R01_B

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Revision	Date	Description	Author
R0	14/10/2019	1st Issue	Arthur Lewis-Nunes
A	19/03/2020	Planning Issue	Arthur Lewis-Nunes
B	12/05/2022	Updated Plant Proposals	Arthur Lewis-Nunes

CONTENTS

1 INTRODUCTION

ALN Acoustic Design has been appointed to carry out a noise assessment in relation to the proposed replacement of the ventilation and cooling plant equipment at the Ambassadors Theatre, West Street, London WC2H 9ND in the London Borough of Camden.

This report presents the results of a background noise survey at the site and assesses the noise generated by the proposed equipment with regard to the Camden Council plant noise criteria and BS4142:2014 guidance.

This report has been prepared by Arthur Lewis-Nunes MSc who is a full member of the Institute of Acoustics.

A glossary of technical terminology used in this report is provided in Appendix A.

2 THE SITE

There are a number of items of plant equipment located on the roof of the building which have reached the end of their operational life and need to be replaced. This includes supply and extract fans, a chiller unit plus various smaller condenser units.

The majority of this equipment is located in a centrally located ‘pit’ at lowered roof level. The chiller unit is situated on a separate roof at the northeast elevation.

It is proposed to remove and replace the above equipment with a single air-handling unit plus ten external heat pump condenser units as detailed in Section 5.1.

There are a number of noise sensitive receptors surrounding the site which could potentially be affected by noise from the plant equipment operation.

The theatre is adjoined to a residential building (4-10 Tower Street) and an office building (24 West Street). The rear elevation of 4-10 Tower Street overlooks the main plant equipment area. The front elevation is orientated away from the existing chiller unit, which is obscured from view by the corner of the building (the side elevation does not contain any windows).

It is understood that the former school building at 22 Tower Street has recently been converted to residential. This building lies approximately 11m from the existing chiller.

There are further residential premises on the upper floors of Tower Court and on Lichfield Street, both of which are at a greater distance.

St Martin's Theatre is located to the west of the building. The façade which faces the Ambassadors Theatre comprises back of house spaces and is not considered to be acoustically sensitive.

An aerial image of the site and surrounding area is provided in Figure 1 in which the main noise sensitive receptor locations are indicted.

Figure 1: Aerial image of site and surrounding area

3 ASSESSMENT CRITERIA

The site is located within the London Borough of Camden. The Camden Council Local Plan (2017) sets out the criteria for noise and vibration used to determine applications for planning permission.

Policy A4: Noise and Vibration is reproduced below:

> The Council will seek to ensure that noise and vibration is controlled and managed.
>
> Development should have regard to Camden's Noise and Vibration Thresholds (Appendix 3). We will not grant planning permission for:
>
> a. development likely to generate unacceptable noise and vibration impacts; or
> b. development sensitive to noise in locations which experience high levels of noise, unless appropriate attenuation measures can be provided and will not harm the continued operation of existing uses.
>
> We will only grant permission for noise generating development, including any plant and machinery, if it can be operated without causing harm to amenity. We will also seek to minimise the impact on local amenity from deliveries and from the demolition and construction phases of development.

Appendix 3 of the Local Plan sets out the thresholds that will be considered by the council when assessing applications. The relevant section which is applicable to the assessment of plant and machinery noise at dwellings is reproduced below:

Existing Noise sensitive receptor	Assessment Location	Design Period	LOAEL (Green)	LOAEL to SOAEL (Amber)	SOAL (Red)
Dwellings**	Garden used for main amenity (free field) and Outside living or dining or bedroom window (façade)	Day	'Rating level' 10dB* below background	'Rating level' between 9dB below and 5dB above background	'Rating level' greater than 5dB above background
Dwellings**	Outside bedroom window (façade)	Night	'Rating level' 10dB* below background and no events exceeding 57dB L_{Amax}	'Rating level' between 9dB below and 5dB above background or noise events between 57dB and 88dB L_{Amax}	'Rating level' greater than 5dB above background and/or events exceeding 88dB L_{Amax}

The thresholds evaluate impact in terms of various 'effect levels' as described in the National Planning Policy Framework and Planning Practice Guidance. There are corresponding design criteria which guide applicants as to the degree of detailed consideration needed to be given to noise in any planning application. The thresholds and design criteria are as set out below:

- Green – where noise is considered to be at an acceptable level.
- Amber – where noise is observed to have an adverse effect level, but which may be considered acceptable when assessed in the context of other merits of the development.
- Red – where noise is observed to have a significant adverse effect.

Appendix 3 of the Local Plan indicates that it is expected that the BS4142:2014 assessment methodology will be used.

3.1 BS4142

BS4142:2014 'Methods for rating and assessing industrial and commercial sound' is the current British Standard which provides an established methodology for the assessment of the impact of noise from fixed mechanical and electrical plant and equipment.

The degree of adverse impact for a particular noise source is dependent upon factors including the extent by which it exceeds the background noise level, the character of the noise and its time of occurrence.

A 'Rating Level' for the specific source is established, which has been corrected to account for the characteristics of the sound, including having noticeable tonality, being intermittent / impulsive, or having any other distinct characteristics which would make it more noticeable.

Levels of impact are defined in terms of the Rating Level relative to the background noise level, as set out in Table 1 below.

Rating Level relative to background level	**Assessment**
0dB or less than background	'An indication of the specific sound source having a low impact, depending on context'
5dB or more than background	'Likely to be in indication of an adverse impact, depending on context'
10dB or more than background	'Likely to be in indication of a significant adverse impact, depending on context'

Table 1: BS4142 defined levels of impact

4 NOISE SURVEY

4.1 Methodology

A survey of background noise levels was carried out from Friday 27th until Monday 30th September 2019.

A weather-protected Class 1 sound level meter and tripod-mounted microphone were installed on the roof of the theatre in the position marked 'MP1' in Figure 1 (further details of the instrumentation used are provided in Appendix B).

The sound level meter was set up to record noise levels at consecutive 15-minute intervals throughout the survey period. The existing plant equipment was operational during certain parts of the survey, corresponding to the time leading up to and including shows on Friday and Saturday evening.

Noise levels were subsequently measured over a period of one hour starting at 19:35 on Tuesday 08/10/2019 at ground level at the corner of Tower Street Tower Court.

No access to the rear terraces of 4-10 Tower Street was available. However, the measurements at MP1 are considered to be reasonably representative as they are at a similar distance to the existing plant equipment which is the main source of background noise locally.

The measurements at MP2 are considered to be representative of those occurring at the facade of 22 Tower Street.

4.2 Survey Results

The time history plot of the noise survey data from MP1 is presented below in Figure 2. The recorded background noise levels ranged from 47 to 59dB $L_{AF90,15min}$.

The proposed plant equipment will generally be operational during the opening hours of the theatre, i.e. daytimes and evenings from Monday to Saturday, and is not expected to be operational beyond 11.30pm. The representative background noise level at these times is 55dB $L_{AF90,15min}$.

Noise levels measured at MP2 are presented in Table 2. Based on the measured levels, it is considered that the representative background noise level at MP2 is 53dB $L_{AF90,15min}$.

The representative background noise levels at the nearby receptors are therefore as follows:

- 4-10 Tower Street: 55dB L_{AF90}
- 22 Tower Street: 53dB L_{AF90}

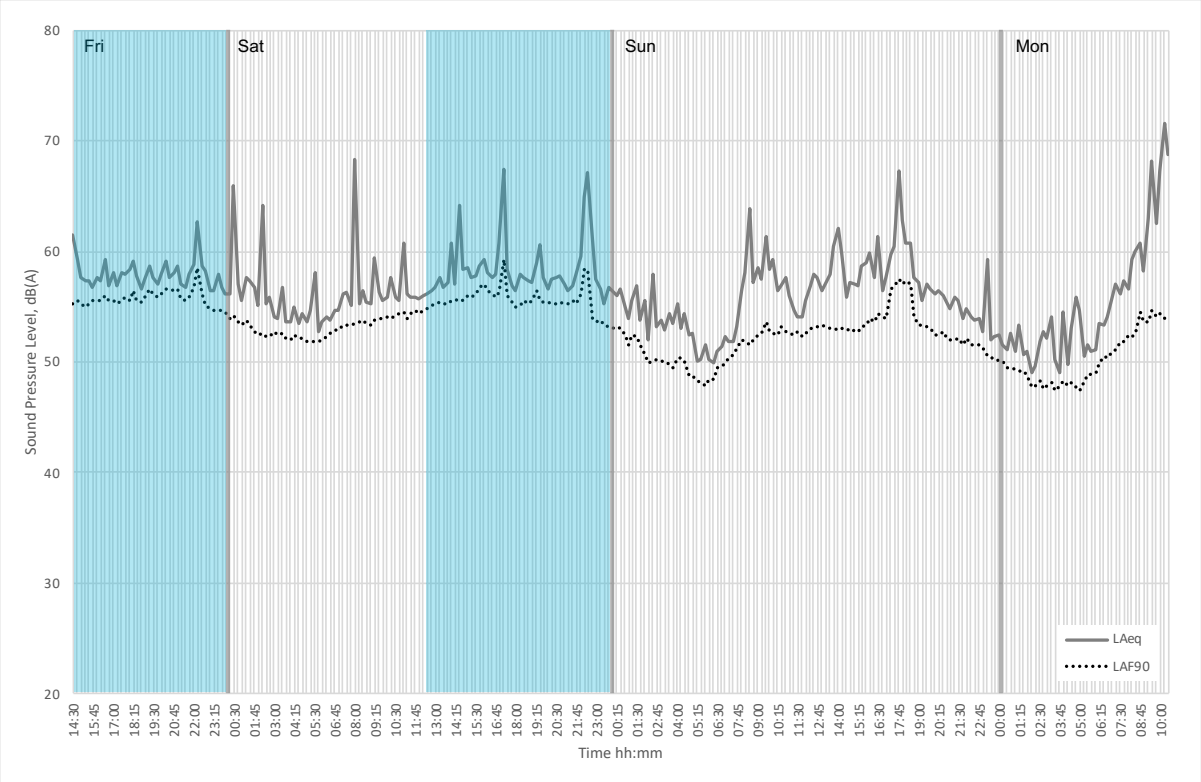


Figure 2: Noise survey data (MP1)

Start Time	Noise Level	
	$L_{Aeq,15min}$ (dB)	$L_{AF90,15min}$ (dB)
19:35	65	53
19:50	59	53
20:05	69	55
20:20	67	56

Table 2: Noise survey results (MP2)

5 PLANT NOISE ASSESSMENT

5.1 Plant Equipment

The M&E consultants, PowerPlan, have advised that the proposed external plant equipment is as set out in the table below.

Equipment Type	Manufacturer & Model Ref	Quantity	Noise Output
Heat Pump	Mitsubishi PUZ-ZM250	5	62 dBA @ 1m
Outdoor Unit	Mitsubishi MXZ-5F102	2	56 dBA @ 1m
Outdoor Unit	Mitsubishi PUZ-ZM71	1	49 dBA @ 1m
Outdoor Unit	Mitsubishi MXZ-3F68	2	53 dBA @ 1m
AHU	MY Ventilation ADQ11639-01-A	1	71 dB(A) SWL intake 78 dB(A) SWL exhaust

Table 3: Proposed plant equipment (provisional selection) and manufacturer's noise data

All of the above equipment is to be located on the roof of the theatre as indicated in the roof plan provided in Appendix C.

The air-handling unit is to be located above the central roof area. Duct attenuators are to be fitted to the air intake and exhaust connections.

The heat pumps are to be located at the southeast corner of the roof near to the West Street elevation. The outdoor units are to be located in the southern corner of the roof and also the roof to the north of the building on to the Tower Street elevation.

5.2 Plant Noise Calculations

The resultant noise level at the noise sensitive receptors due to the operation the plant equipment has been calculated using the manufacturer's published octave-band noise data, accounting for the effects of distance attenuation, screening and reflections (where applicable).

The overall noise level is calculated by logarithmically summing the individual emissions from each item of plant equipment including the contributions from the AHU casing, air intake and exhaust terminals. It is conservatively assumed that all the plant equipment will be operating simultaneously. Attenuators are to be fitted to the intake and exhaust of the AHU with minimum dynamic insertion losses as set out in the calculation tables below.

Noise levels have been calculated at 4-10 Tower Street and 22 Tower Street (see Table 4 and Table 5). The highest noise levels are calculated at the rear facades of 4-10 Tower Street

which has a direct line of sight to the AHU and a number of the outdoor condenser units. The windows at this façade will be partially screened from noise from the five Mitsubishi PUZ-ZM250 units, reducing the noise received from these units by approximately 5dB. These windows are facing in the opposite direction to the roof with the Mitsubishi MXZ-3F68 units and will therefore be more effectively screened from the noise they emit.

22 Tower Street is generally further away from most the rooftop plant equipment and screened by the fly tower roof, with the exception of the Mitsubishi MXZ-3F68 which are overlooked by the windows at this address. However, these units have a relatively noise output and the overall plant noise level is expected to be lower than at 4-10 Tower Street.

Frequency, Hz			63	125	250	500	1000	2000	4000	8000	A
Outdoor Units											
Mitsubishi MXZ-5F102											
SPL @1m, dB	2	no.	57	62	58	54	50	45	39	30	56
Distance:	22	m	-27	-27	-27	-27	-27	-27	-27	-27	
SPL @ reciever			33	38	34	30	26	21	15	6	**32**
Mitsubishi PUZ-ZM250											
SPL @1m, dB	5	no.	71	61	60	61	57	53	43	42	62
Distance:	16	m	-24	-24	-24	-24	-24	-24	-24	-24	
Screening attenuation			-5	-5	-5	-5	-5	-5	-5	-5	
SPL @ reciever			49	39	38	39	35	31	21	20	**40**
Mitsubishi PUZ-ZM71											
SPL @1m, dB	1	no.	57	62	58	54	50	45	39	30	56
Distance:	16	m	-24	-24	-24	-24	-24	-24	-24	-24	
SPL @ reciever			33	38	34	30	26	21	15	6	**32**
Mitsubishi MXZ-3F68											
SPL @1m, dB	2	no.	59	59	54	51	48	43	36	28	53
Distance:	9	m	-19	-19	-19	-19	-19	-19	-19	-19	
Screening attenuation			-6	-8	-9	-12	-14	-17	-20	-23	
SPL @ reciever			36	35	28	23	18	10	0	-11	**25**
AHU Breakout											
SWL , dB			75	74	68	53	53	49	52	44	63
Distance:	10	m									
Distance attenuation, dB			-25	-25	-25	-25	-25	-25	-25	-25	
SPL @ reciever			50	49	43	28	28	24	27	19	**38**
AHU Exhaust Outlet											
SWL outlet, dB			74	75	72	72	71	69	66	59	76
Attenuator Insertion Loss, dB			-3	-6	-11	-19	-24	-24	-15	-11	
Distance:	11	m									
Distance attenuation, dB			-29	-29	-29	-29	-29	-29	-29	-29	
SPL @ reciever			42	40	32	24	18	16	22	19	**30**
AHU Supply Inlet											
SWL inlet, dB			73	74	74	67	64	60	60	48	71
Attenuator Insertion Loss, dB			-3	-6	-11	-19	-24	-24	-15	-11	
Distance:	15	m									
Distance attenuation, dB			-32	-32	-32	-32	-32	-32	-32	-32	
Reflections, dB			3	3	3	3	3	3	3	3	
SPL @ reciever			41	39	34	19	11	7	16	8	**29**
Total SPL at window, dB			53	51	46	40	37	33	30	24	**43**

Table 4: Plant noise calculation (4-10 Tower Street)

Frequency, Hz			63	125	250	500	1000	2000	4000	8000	A
Outdoor Units											
Mitsubishi MXZ-5F102											
SPL @1m, dB	2	no.	57	62	58	54	50	45	39	30	56
Distance:	37	m	-31	-31	-31	-31	-31	-31	-31	-31	
SPL @ reciever			29	34	30	26	22	17	11	2	**28**
Mitsubishi PUZ-ZM250											
SPL @1m, dB	5	no.	71	61	60	61	57	53	43	42	62
Distance:	32	m	-30	-30	-30	-30	-30	-30	-30	-30	
Screening attenuation			-5	-5	-5	-5	-5	-5	-5	-5	
SPL @ reciever			43	33	32	33	29	25	15	14	**34**
Mitsubishi PUZ-ZM71											
SPL @1m, dB	1	no.	57	62	58	54	50	45	39	30	56
Distance:	37	m	-31	-31	-31	-31	-31	-31	-31	-31	
SPL @ reciever			26	31	27	23	19	14	8	-1	**25**
Mitsubishi MXZ-3F68											
SPL @1m, dB	2	no.	59	59	54	51	48	43	36	28	53
Distance:	11	m	-21	-21	-21	-21	-21	-21	-21	-21	
Screening attenuation											
SPL @ reciever			41	41	36	33	30	25	18	10	**35**
AHU Breakout											
SWL , dB			75	74	68	53	53	49	52	44	63
Distance:	25	m									
Distance attenuation, dB			-33	-33	-33	-33	-33	-33	-33	-33	
Screening attenuation			-5	-5	-5	-5	-5	-5	-5	-5	
SPL @ reciever			37	36	30	15	15	11	14	6	**25**
AHU Exhaust Outlet											
SWL outlet, dB			74	75	72	72	71	69	66	59	76
Attenuator Insertion Loss, dB			-3	-6	-11	-19	-24	-24	-15	-11	
Distance:	25	m									
Distance attenuation, dB			-36	-36	-36	-36	-36	-36	-36	-36	
Screening attenuation			-5	-5	-5	-5	-5	-5	-5	-5	
SPL @ reciever			30	28	20	12	6	4	10	7	**18**
AHU Supply Inlet											
SWL inlet, dB			73	74	74	67	64	60	60	48	71
Attenuator Insertion Loss, dB			-3	-6	-11	-19	-24	-24	-15	-11	
Distance:	26	m									
Distance attenuation, dB			-36	-36	-36	-36	-36	-36	-36	-36	
Reflections, dB			3	3	3	3	3	3	3	3	
SPL @ reciever			37	35	30	15	7	3	12	4	**24**
Total SPL at window, dB			46	44	40	37	33	29	22	17	**39**

Table 5: Plant noise calculation (22 Tower Street)

5.3 Noise Assessment

The analysis presented above indicates that the highest noise level will be 43dB(A) at rear facade of 4-10 Tower Street. This is 12dB below the representative background noise level during the hours of use.

BS4142:2014 advises that a plant noise rating level not exceeding the background noise level is '*an indication of the specific sound source having a low impact, depending on context*'.

The proposed plant equipment will replace existing plant equipment and will therefore not introduce noise out of character with the existing noise climate. It is therefore concluded that the proposed plant noise level of at least 12dB below the background noise level will have a low impact.

The Camden Local Plan classifies a plant noise level 12dB below the background level as being below the lowest observable adverse effect level and therefore considered to be acceptable.

6 SUMMARY

A site noise survey has been carried out to establish existing background noise levels at the noise sensitive receptors located near to the Ambassadors Theatre.

The resultant noise level due to the operation of proposed replacement plant equipment has been calculated based on the manufacturer's published noise data.

The calculated plant noise level is at least 12dB lower than the representative background noise level.

An assessment following the procedure set out in BS4142:2014 indicates that plant noise at this level will have a low impact.

Based on the plant equipment selection, it is concluded that it can be operated without causing harm to the local amenity, as required by policy A4 of the Camden Local Plan.

APPENDIX A - GLOSSARY OF ACOUSTIC TERMINOLOGY

EQUIVALENT CONTINUOUS A-WEIGHTED, $L_{Aeq,T}$

The level of a notional continuous sound that would contain the same sound energy as the actual fluctuating sound over the time period, T. Weighted over frequencies to approximate the sensitivity curve of human hearing (A-weighted).

BACKGROUND NOISE LEVEL, $L_{AF90,T}$

The A-weighted sound pressure level of a fluctuating sound that is exceed for 90% of the time interval, T.

A-WEIGHTED MAXIMUM NOISE LEVEL, L_{AFmax}

The maximum A-weighted sound pressure level recorded over the period stated, measured using the “fast” time constant.

SOUND REDUCTION INDEX, R

The quantity which describes the level by which a material or building element reduces noise transmission at a given frequency, derived from laboratory measurement.

WEIGHTED SOUND REDUCTION INDEX, R_W

Single Integer number found by comparing the measured Sound Reduction Index spectrum with the 'standard' curves for airborne sound insulation, according to a weighting method described in BS EN ISO 717-1.

APPENDIX B - NOISE MONITORING EQUIPMENT DETAILS

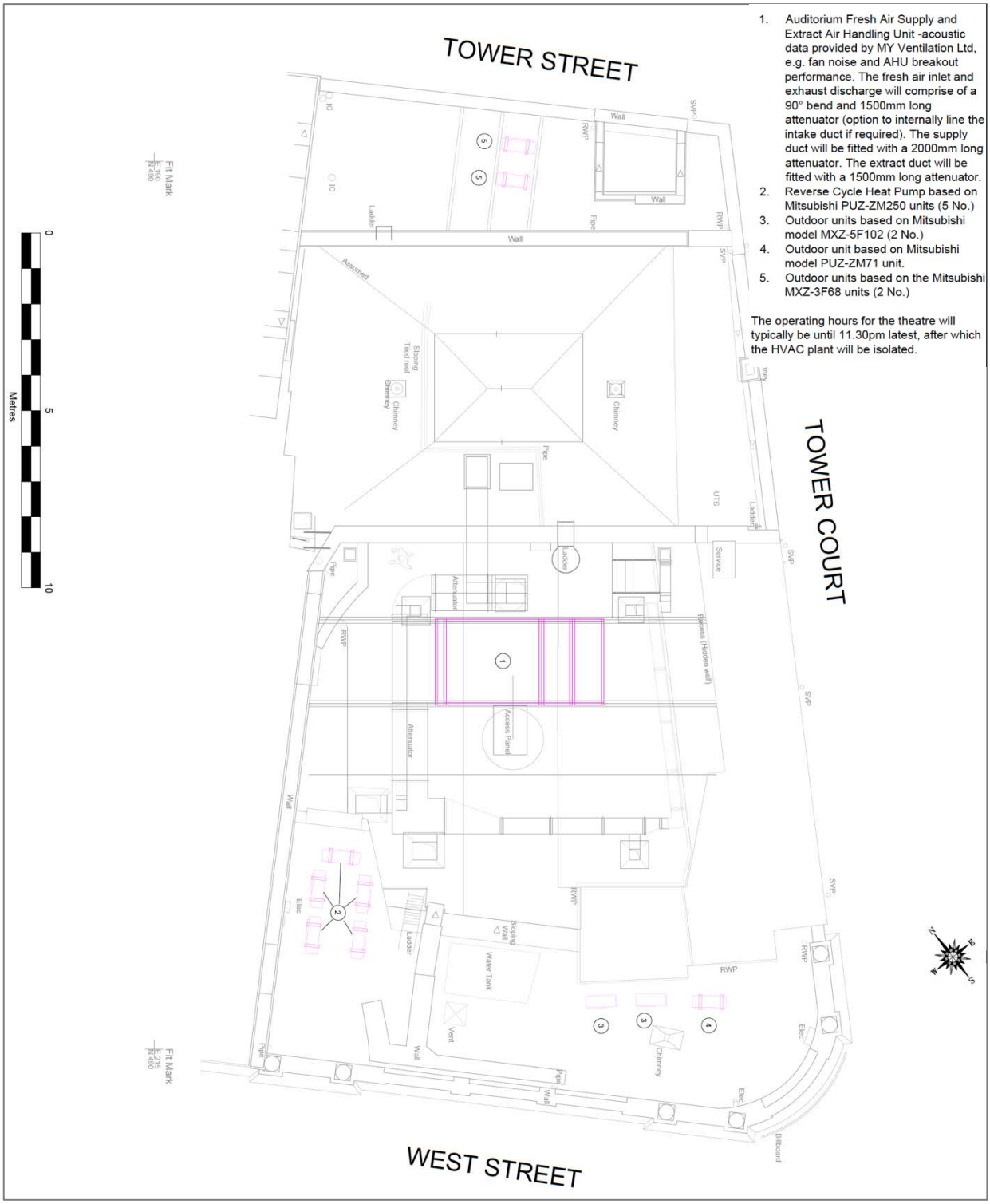
The measurements were made with an NTi XL2 sound level analyser with a GRAS weather protection kit. This equipment complies with BS EN IEC 61672 class 1.

The calibration of the sound level meter was checked at the beginning and end of measurements with a Larson David CAL200 sound calibrator, complying with BS EN IEC 60942 class 1. No significant calibration deviation occurred.

The table below lists the serial numbers and last calibration dates of the equipment used.

Description	Serial No.	Calibration Date
NTi XL2 Sound Level Meter	A2A-16249-E0	02/07/2019
NTi MC230A Condenser Microphone	A17342	02/07/2019
NTi MA220 Pre-Amplifier	8450	02/07/2019
Larson David CAL200 Sound Calibrator	16795	02/07/2019

APPENDIX C - HVAC PLANT LOCATIONS



APPENDIX D - MANUFACTURERS' NOISE DATA

1. Auditorium Air Handling Unit

Based on the MY Ventilation proposal reference MY 11369

-

Project:	Ambassadors Theatre
Quotation Reference:	Q11639
Date:	22 Mar 2022

Customer Unit Reference	**AHU-1**	**Serving**		**AHU 1**			
Unit Reference	ADQ11639-01-A						
Model Reference	Non-standard						
AHU Acoustic Data:							
Acoustic Data (Supply Fan Sound Power Level): Per Fan							
Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply Fan Inlet Lw (dB):	78	80	81	76	75	75	79	69
Supply Fan Outlet Lw (dB):	80	82	81	82	82	80	82	73
Acoustic Data (Extract Fan Sound Power Level): Per Fan							
Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract Fan Inlet Lw (dB)	74	75	75	70	70	72	71	63
Extract Fan Outlet Lw (dB)	76	77	75	76	76	76	74	68
Acoustic Data (Supply AHU Sound Resultant Level):							
Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Supply AHU Inlet Lw (dB)	73	74	74	67	64	60	60	48
Supply AHU Outlet Lw (dB)	78	80	79	80	79	75	72	63
Acoustic Data (Extract AHU Sound Resultant Level):							
Frequency(Hz)	63	125	250	500	1K	2K	4K	8K
Extract AHU Inlet Lw (dB)	73	74	74	69	69	71	69	61
Extract AHU Outlet Lw (dB)	74	75	72	72	71	69	66	59
Resultant AHU Breakout							
Frequency (Hz)	63	125	250	500	1K	2K	4K	8K
Supply Lw (dB)	73	73	67	52	52	48	51	43
Extract Lw (dB)	69	68	61	46	46	43	43	37
AHU Spectrum Lw (dB)	75	74	68	53	53	49	52	44
Resultant AHU Level @ 3m	54	54	48	33	32	28	31	23
Overall AHU "A" weighted Breakout @ 3m	43							

IMPORTANT NOTES

Sound Power levels subject to a correction of +6 dB should be applied across all octave bands for unit casing adjustment

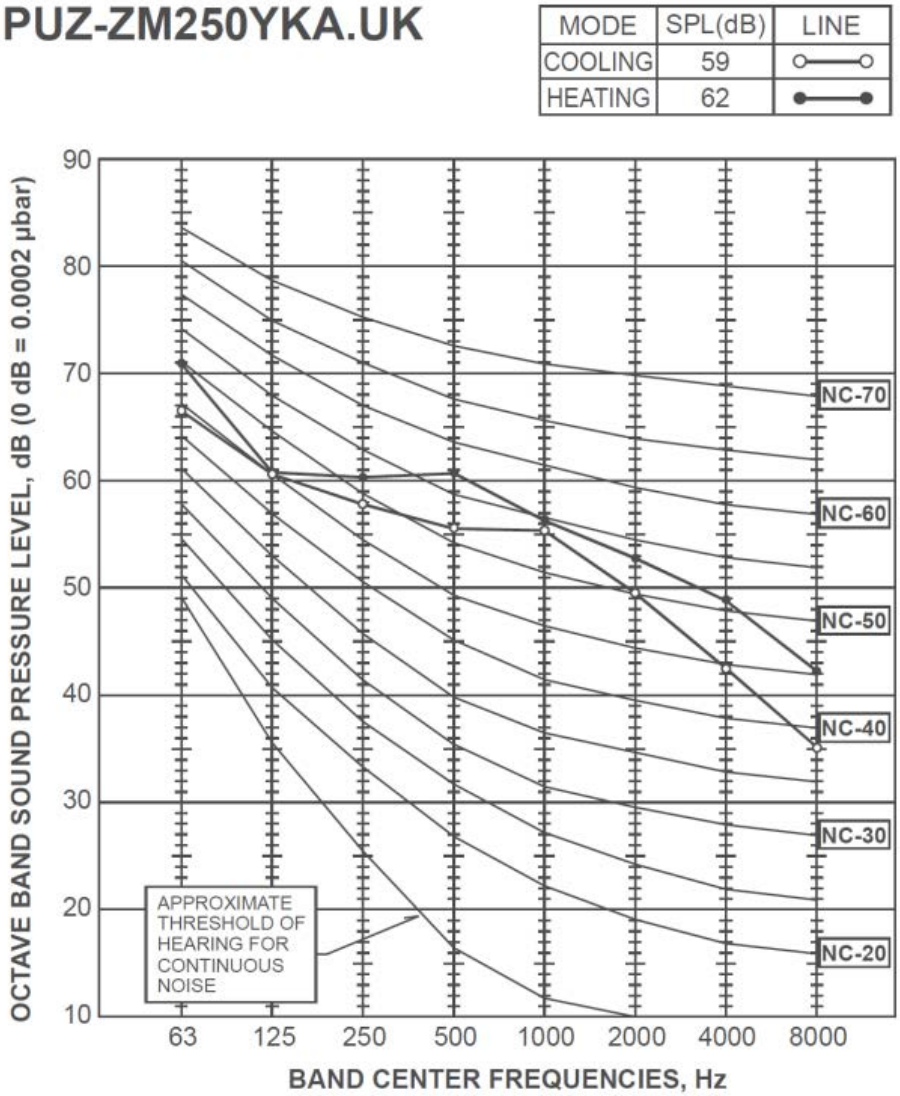
Sound Power levels are Per Fan

The In-duct Sound Power Level Spectra are in dB re-1pW.

The overall A-weighted sound pressure level is at a distance of 3m with spherical free-field propagation. It is expressed in dB re-20 µPa and is presented for comparative purposes only.

Resultant sound pressure includes all selected AHU component losses within the above calculation.

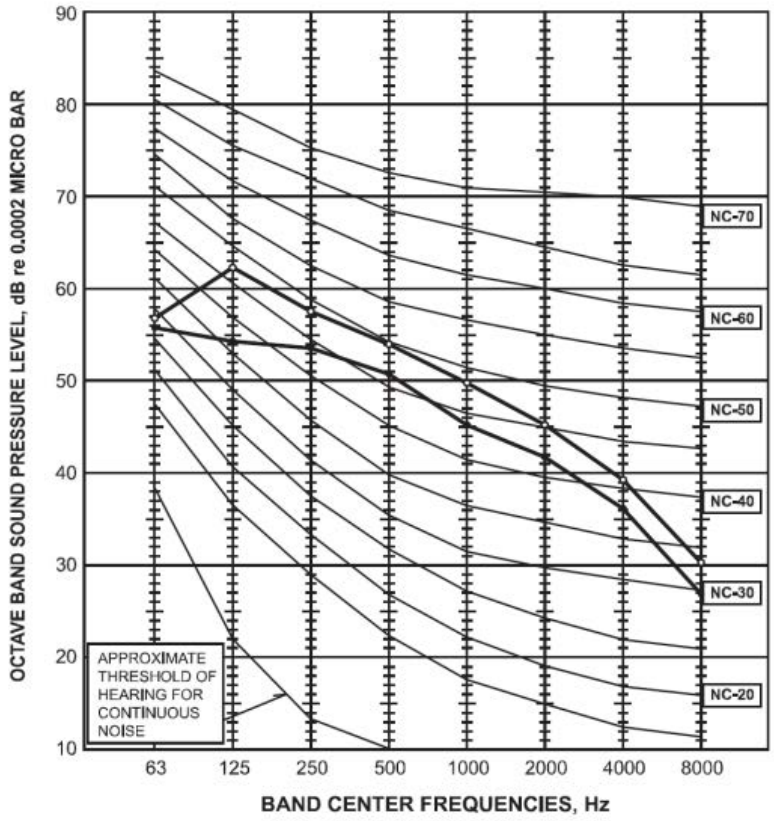
2. Mitsubishi PUZ-ZM250



3. Mitsubishi MXZ-5F102 or MXZ-5E102

MXZ-5E102VA

FAN SPEED	FUNCTION	SPL(dB(A))	LINE
High	Cooling	52	●—●
High	Heating	56	○—○



4. Mitsubishi PUZ-ZM71

PUZ-ZM OUTDOOR UNITS		PUZ-ZM35VKA	PUZ-ZM50VKA	PUZ-ZM60VHA	PUZ-ZM71VHAR1	PUZ-ZM100VKAR1	PUZ-ZM100YKAR1 ③
SOUND PRESSURE LEVEL (dBA)	Heating/Cooling	46 / 44	46 / 44	49 / 47	49 / 47	51 / 49	51 / 49
SOUND POWER LEVEL (dBA)	Cooling	65	65	67	67	69	69
WEIGHT (kg)		46	46	70	70	116	123

5. Mitsubishi MXZ-3F68 or MXZ-3E68

MXZ-3E68VA

FAN SPEED	FUNCTION	SPL(dB(A))	LINE
High	Cooling	50	●—●
High	Heating	53	○—○