Acoustic Assessment of Proposed New Mechanical Services Equipment

6-24 Britannia Street, London, WC1X 9JD

Client: Belshaw

Report Reference: 230212-R001

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Note that consideration of non-acoustic aspects including, but not limited to structural calculations, compliance with Building Regulations and other statutory requirements, or any assessment of fire regulations are outside the scope of ACA Acoustics Limited and should be considered by others accordingly.

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0. SUMMARY

0.1. ACA Acoustics Limited has been commissioned to assess the acoustic impact of proposed new mechanical services equipment to be installed at 6-24 Britannia Street, London.

0.2. The assessment is required to provide evidence that noise emissions from the equipment will not be detrimental to the amenity of nearby noise-sensitive properties and complies with the Local Authority's requirements.

0.3. A survey has been carried out in the vicinity to establish existing background sound levels. The background sound levels during the most sensitive time of the proposed operating hours are LA90 48dB at the monitoring position. Based on London Borough of Camden Council's criteria, noise from the new plant should not exceed a rating level of 38dBA outside the closest noise-sensitive windows.

0.4. The most noise-sensitive residential receptors (NSRs) have been assessed as the front, second floor windows of 14 Leeke Street (NSR1), the rear top floor windows of 5 Leeke Street (NSR2) and the rear top floor window of 13 Leeke Street (NSR3) closest to AHU location.

0.5. Calculations using manufacturer's sound level data for the new equipment, allowing for the recommendations as set out in this report, confirm that the sound level from the new equipment at the receptor is LAr 37dB at the receptor NSR1, LAr 34dB at the receptor NSR2 and LAr 37dB at the receptor NSR3.

0.6. Noise from the proposed equipment will not be disturbing or detrimental to the amenity of any nearby residential or other noise-sensitive receptors and complies with the planning requirements of London Borough of Camden Council.

1. INTRODUCTION

New mechanical services equipment is to be installed at 6-24 Britannia Street, London.

ACA Acoustics Limited has been commissioned by Belshaw to carry out an assessment of noise emissions from the proposed mechanical plant and, where necessary, to make recommendations for a mitigation scheme to ensure that the amenity of nearby noise-sensitive properties is not compromised.

This report presents results of the sound level survey, computer modelling, and assessment.

2. ACOUSTIC CRITERIA

London Borough of Camden Council's policies relating to noise are set out in Appendix 3 of the Local Plan, which provides detailed noise thresholds to determine the potential acoustic impact of new developments.

In summary, London Borough of Camden requires an assessment to be carried out in accordance with British Standard 4142:2014+A1:2019.

The scope of BS 4142:2014+A1:2019 advises that "*this British Standard describes methods for rating and assessing sound of an industrial and/or commercial nature … to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident*". BS 4142:2014+A1:2019 is commonly used to assess the potential for loss of amenity due to noise from mechanical services equipment and is considered appropriate for this application.

The assessment method of BS 4142:2014+A1:2019 corrects the specific sound level from the source under investigation to account for characteristics that could make the sound more intrusive to obtain a rating level. This rating level is compared against the prevailing background sound level outside the noise-sensitive property. Section 11 of BS 4142:2014+A1:2019 provides a commentary of the assessment result and advises that:

a) Typically, the greater this difference [between the rating level and the background sound level]*, the greater the magnitude of the impact.*
b) A difference of around +10dB or more is likely to be an indication of a significant adverse impact, depending on the context.
c) A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.
d) *The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact.*

Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

Rather than use the assessment of the impacts from the Standard, Camden requires that the calculated rating level is compared against noise-related conditions set out in Table C of the Appendix, as shown in Table 1 below:

Existing Noise Sensitive Receptor	**Assessment Location**	**Design Period**	**LOAEL (Green)**	**LOAEL to SOAEL (Amber)**	**SOAEL (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 LAmax	Rating level between 9dB below and 5dB above background or noise events between 57dB and 88dB LAmax	Rating level greater than 5dB above background and/or events exceeding 88dB LAmax

Table 1: London Borough of Camden Noise Limits

The terms "LOAEL" and "SOAEL" are defined as the "Lowest Observed Adverse Effect Level" and "Significant Observed Adverse Effect Level" in the Planning Practice Guidance – Noise (PPG-N) and Noise Policy Statement for England (NPSE). The NPSE and PPG-N both require that significant adverse impacts are avoided and that where the impact lies somewhere between the LOAEL and SOAEL all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life, whilst considering the guiding principles of sustainable development as set out in the National Planning Policy Framework.

Assessment result criteria shown within Appendix A of Camden's Local Plan are more stringent than those set out in the British Standard and can therefore be taken to ensure a robust assessment. Compliance with the "Green" criteria or lower half of the "Amber" range will generally ensure no loss of amenity to nearby residents.

3. REVIEW OF SITE LOCATION

New mechanical equipment, comprising of six air conditioning condensers and one air handling unit are being installed on the rooftop at the rear of the site. Four of the air conditioning condensers and AHU will be located on the western corner of the roof with a 2m high existing screen at the edge of the roof. The remaining two air conditioning condensers will be on the north-eastern part of the roof.

The most noise-sensitive residential receptors (NSRs) have been assessed as the second floor windows of 14 Leeke Street for the equipment to be installed on the western part of the roof, indicated by the NSR1 label below. The NSR2 label is indicative of the receptor to the other two air conditioning condensers, which will be the rear, top floor window of 5 Leeke Street, overlooking the plant location. The NSR3 label highlights NSR3, which is the rear, top floor window of 11 Leeke Street, closest to the AHU location.

A marked-up aerial image is included in Figure 1, identifying the location of the proposed equipment and sound level survey measurement position.

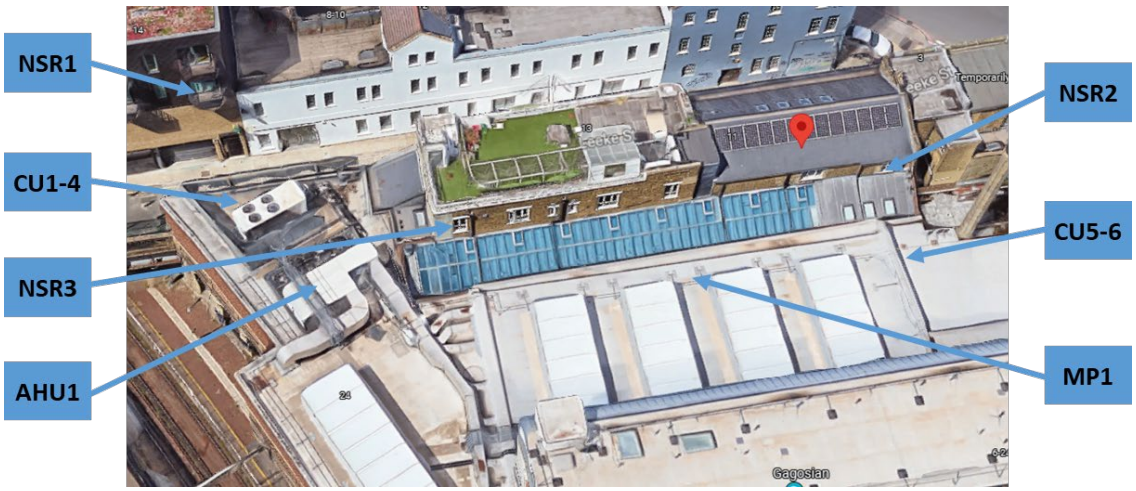

Figure 1: Equipment location, measurement position, and closest receptor (available at google.com/maps)

Proposed operating times of the equipment are presumed to be office hours between 07:00 and 20:00.

4. SOUND LEVEL SURVEY

To assess sound levels from the new mechanical equipment, it is necessary to establish representative background sound levels in the vicinity during the proposed plant operating times.

The background sound level was measured via an unattended survey at the position indicated in Figure 1 (MP1). This position was considered as being representative of the NSR1, NSR2 and NSR3

receptors. The survey was set up by Sam Thorpe of ACA Acoustics and conducted between the 27th and 28th March 2023.

The microphone was set up on the edge of the rear roof near to the residential buildings to the north. With plant on both sides of the roof, this was the quietest part and therefore provides a more robust assessment and more representative level for that at the receptors.

During the survey, the soundscape in the vicinity was influenced predominantly by local traffic and the nearby train activity. Some plant was also contributory to the sonic environment at the measurement position.

The following equipment was used during the survey. An on-site calibration check was conducted on the sound level meter prior to the survey and repeated after with no deviation noted.

Equipment	**Serial Number**
Rion Class 1 sound level meter type NL-52, complete with weatherproof and lockable outdoor environmental kit	00564867
Svantek calibrator type SV33B. Compliant to IEC 60942-1:2003	83826

Table 2: Equipment used for the sound level survey

Weather conditions at the time of setting up the survey were cool and dry with varied cloud cover and a light breeze. Weather conditions have been reviewed at www.worldweatheronline.com, using the closest available commercial weather station. Weather conditions remained predominantly calm and dry with wind speeds below recommended limits during the proposed equipment operation times. Meteorological conditions are considered acceptable and will not have adversely impacted the survey results.

Results of the survey are shown in graphical form in Figure 2 below.

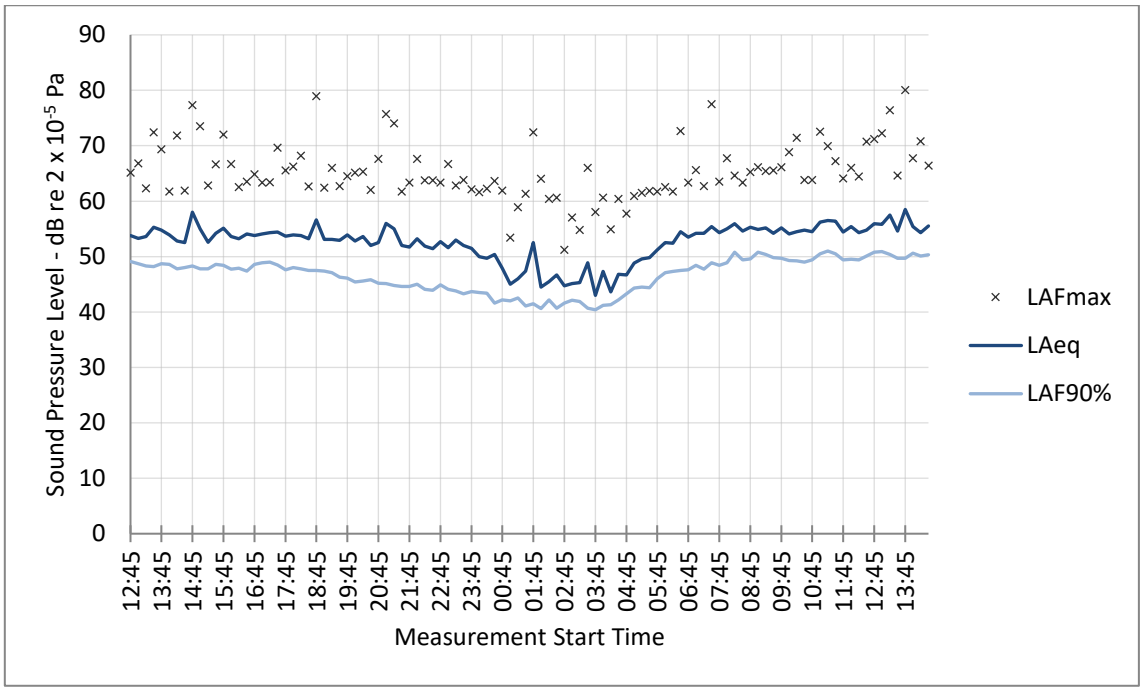

Figure 2: Sound level survey results – 27th-28th March 2023

In accordance with the methodology set out in BS 4142:2014+A1:2019, the background sound level is not necessarily the lowest recorded value. Instead, the background sound level should be a level which is representative of the underlying soundscape at the receptor location.

A statistical analysis of the measured LA90 results during the proposed operating times of the equipment is shown in Figure 3 below, following guidance set out in the Standard.

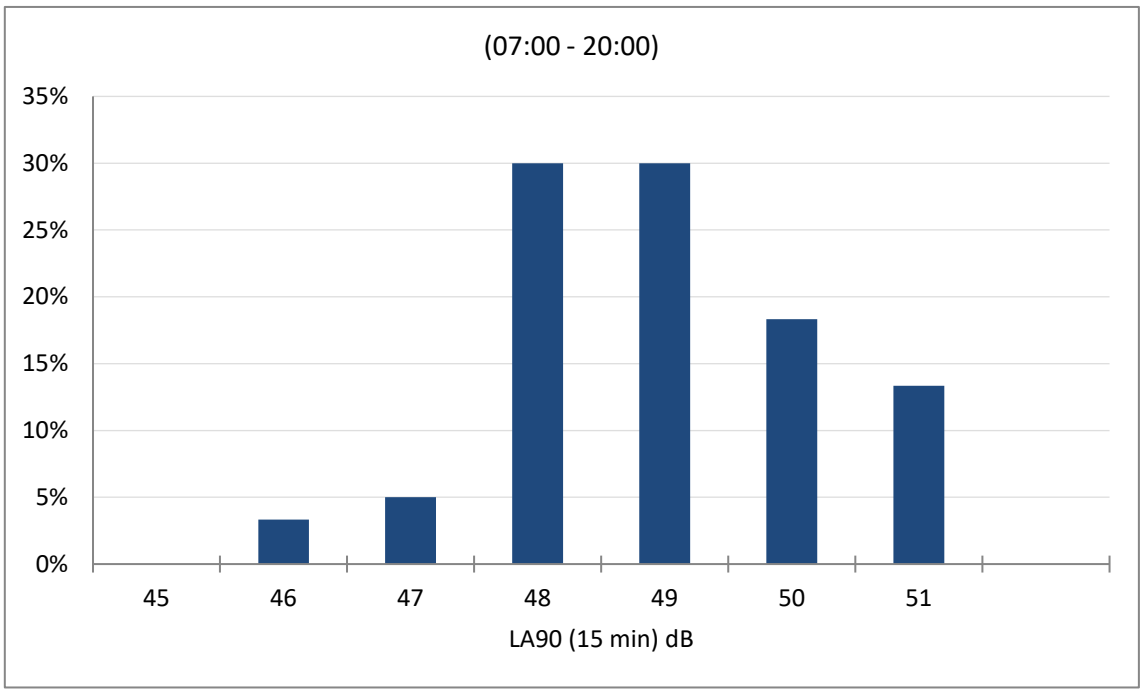

Figure 3: Statistical analysis of measured LA90 sound levels during the assessment period

Based on the statistical analysis of the survey results, the author considers a level of LA90 48dB is representative of the background sound level in the vicinity.

Summary results of the survey are provided in Table 2 below.

Receptor	Period	Representative Background Sound Level During Operating Period LA90
NSR1-3	07:00-20:00	48dB

Table 3: Summary sound level survey results

5. ACOUSTIC ASSESSMENT

The development includes the installation of new extract and supply fans. Confirmation of the equipment models used in the assessment is provided in Table 3 below.

Description	Equipment Model	Airflow (m3/s)	Sound Level (LwA)	Quantity
AC Condenser CU1	PUMY-P140YKM4	N/A	71dB	1
AC Condenser CU2	PURY-P300YNW-A	N/A	86dB	1
AC Condenser CU3	PURY-P500YNW-A	N/A	84dB	1
AC Condenser CU4	PURY-P600YNW-A	N/A	89dB	1
AC Condensers CU5 & CU6	PUZ-WM112VAA	N/A	60dB	2
AHU1 Fresh Intake	PUZ ZM250YKA	2.8	71dB	1
AHU1 Supply	PUZ ZM250YKA	2.8	54dB	1
AHU1 Return	PUZ ZM250YKA	2.8	54dB	1
AHU1 Exhaust	PUZ ZM250YKA	2.8	71dB	1

Table 4: Proposed new mechanical equipment used in the assessment

A computer model has been used to calculate the noise contribution from the proposed plant to outside nearest noise-sensitive windows, using manufacturer's published sound data for the proposed new plant. Ductwork system losses have been calculated in accordance with CIBSE Guide

B4 *Noise and vibration control for HVAC*. Environmental corrections have been calculated in accordance with ISO 9613-2.

The assessment has been undertaken using drawing reference 41839(50)SK003, as provided by the client.

Mitigation recommendations outlined in Section 6 of this report are included in the computer model.

The cumulative calculated specific sound level to outside the most sensitive receptors with all equipment operating is shown in Table 4 below. Summary printouts from the calculation models are included in Appendix A.

Receptor Location	**Calculated Equipment Sound Level (All plant operating)**
NSR1	37dBA
NSR2	34dBA
NSR3	37dBA

Table 5: Calculated cumulative equipment sound levels at 1m outside noise-sensitive windows

Assessment of the calculated rating levels in accordance with BS 4142:2014+A1:2019 is provided in Table 5 below.

Description	NSR1 Receptor (All Plant)	NSR2 Receptor (All Plant)	NSR3 Receptor (All Plant)	Relevant Clause	Commentary
Calculated specific sound level to receptor	LAeq 37dB	LAeq 34dB	LAeq 37dB	7.1 7.3.6	New equipment operating. Refer to calculation sheets in Appendix A.
Background sound level	LA90 48dB	LA90 48dB	LA90 48dB	8.1.3 8.3	Measured representative background sound level.
Acoustic feature correction	0dB	0dB	0dB	9.2	The calculated specific sound levels do not indicate any distinctive component and the equipment will be significantly below the background and residual sound levels.
Rating level	LAr 37dB	LAr 34dB	34dB	9.2	
Excess of rating level over background sound level	-11dB	-14dB	-11dB	11	Assessment indicates negligible likelihood of adverse impact

Table 6: Assessment of results in accordance with BS 4142:2014+A1:2019

Table 5 shows the rating level of the proposed new equipment will be at least 10dB below the background LA90 sound level to outside the closest noise-sensitive properties.

BS 4142:2014+A1:2019 requires an assessment to consider the context of the development, in addition to adhering to numerical values. Considering the calculated numerical value of the specific sound, allowing a reduction through partially open windows of 15dBA, as recommended in BS 8233:2014, sound levels inside the neighbouring dwellings due to the proposed new equipment will be approximately 22dBA (37dBA – 15dBA). This is significantly below guideline levels for sleeping in bedrooms of LAeq 30dB, set out in BS 8233:2014 and is further confirmation that sound levels from the new mechanical equipment should not be detrimental to the amenity of any noise-sensitive receptors in the vicinity.

Additionally, the proposals involve new items of mechanical equipment being introduced to an area with other commercial and retail uses in the vicinity. In this scenario, the change in acoustic character, and subsequent potential for loss of amenity, is lower than if, say, there were no other similar developments in the area.

The author considers that the context of the assessment does not alter the initial estimate of the impact, and that sound levels from the new mechanical equipment should not be detrimental to the amenity of any residential occupiers in the vicinity.

6. ACOUSTIC MITIGATION TREATMENTS

As discussed in Section 5, noise control treatments have been included in the calculation model. Acoustic specification for the mitigation scheme is provided below.

6.1. High Performance Acoustic Enclosures

It is recommended that the condensers to the western side of the roof (CU1-4) are installed in a high-performance acoustic enclosure such as those supplied by Environ Technologies Limited or equal and approved. Acoustic performance of a suitable enclosure is shown in Appendix B.

6.2. Louvred Enclosure

It is advised that an acoustic louvre is applied surrounding the two condensing units on the north-eastern side of the roof (CU5-6). A single louvre may be installed over both condensers, with no gaps at the edges. A suitable louvred enclosure would typically be formed from 150mm deep acoustic louvres such as Allaway Acoustic's AL1515 model or equivalent. Minimum insertion loss performance for the louvres is shown on the schedule in Appendix B.

Structural supports/steelwork and access panels or doors may be required and should be determined by the successful supplier accordingly.

6.3. Vibration Isolators

To control the potential for structure-borne noise and vibration from the mechanical equipment affecting adjoining residential and commercial occupants, it is recommended that the plant is installed on vibration isolators.

Vibration isolators for the AHU would typically be steel spring type mounts. The isolator supplier would be able to select a suitable model to provide minimum 98% isolation efficiency at the working load and operating speed. Flexible connections should be fitted between the fans and adjoining ductwork both sides. Suitable vibration isolators for the condensers are typically rubber or neoprene turret type mounts or pads, providing minimum 8mm deflection at the working load. The isolator supplier should ensure their selection is suitable allowing for the condenser operating speed, point load, and installation location.

6.4. Duct Mounted Attenuators

The calculation model includes benefit of duct-mounted attenuators to the Fresh Intake and Exhaust fans of AHU1. A schedule of minimum dynamic insertion loss performance for the attenuators along with description of typical silencer to comply with the specified performance is provided in Appendix B. Note that the dimensions and free-area shown are nominal and the successful supplier should confirm their own selections to meet the minimum specified insertion loss performance.

Any transformation sections between the fan and attenuator should be formed with double-skinned casings.

It is important airflow generated noise from the atmospheric terminal does not increase the cumulative sound level at nearby noise-sensitive properties. Suitable airflow velocity is dependent on the profile of the terminal used and should be verified with the manufacturer accordingly.

6.5. Orientation

In order to achieve the Local Authority's criteria at NSR1, the condensers on the western part of the roof (CU1-4) must be angled such that they face away from the receptors. This is in addition to the mitigation measures outlined above.

7. CONCLUSION

A planning application is to be submitted for the installation of new mechanical plant and equipment at 6-24 Britannia Street, London.

ACA Acoustics have undertaken an assessment of noise from the proposed equipment using manufacturer's published acoustic data. Calculated rating sound levels for the plant is at least 10dB below the background sound level during proposed operating times of the equipment when assessed at 1m from the closest noise-sensitive windows of residential receptors.

The author considers that allowing for the proposed mitigation scheme in this report, the proposed equipment achieve the Local Authority's planning requirements for this development and will not be detrimental to the amenity of nearby noise-sensitive occupants.

Appendix A

Acoustic Calculations

Calculation Sheet

CU1 to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU1								
Sound Power Levels	**78.0**	**78.0**	**69.0**	**71.0**	**65.0**	**60.0**	**55.0**	**50.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-28.1	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.8*
Agr - Ground Attenuation								
	3.0	*1.3*	*0.9*	*1.4*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-8.3	*-7.0*	*-7.4*	*-9.2*	*-11.0*	*-13.2*	*-15.8*	*-18.5*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**36.6**	**34.2**	**18.4**	**10.1**	**-3.6**	**-12.9**	**-20.6**	**-30.0**

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Calculation Sheet

CU2 to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU2								
-	**100.5**	**87.5**	**87.5**	**85.0**	**79.0**	**74.5**	**69.5**	**64.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	0.9	*-1.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*
Adiv - Geometrical Divergance								
	-28.1	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.8*
Agr - Ground Attenuation								
	3.0	*1.3*	*0.9*	*1.4*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-8.3	*-7.0*	*-7.4*	*-9.2*	*-11.0*	*-13.2*	*-15.8*	*-18.5*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**57.0**	**39.7**	**30.9**	**18.1**	**4.4**	**-4.4**	**-12.1**	**-22.0**

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Calculation Sheet

CU3 to NSR1

	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Noise Source								
Noise Source - CU3								
Noise Levels	**97.0**	**87.5**	**86.0**	**81.0**	**75.5**	**73.5**	**70.5**	**64.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	0.1	*-2.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*
Adiv - Geometrical Divergance								
	-28.1	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.8*
Agr - Ground Attenuation								
	3.0	*1.3*	*0.9*	*1.4*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-8.3	*-7.0*	*-7.4*	*-9.2*	*-11.0*	*-13.2*	*-15.8*	*-18.5*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**52.7**	**38.7**	**29.4**	**14.1**	**0.9**	**-5.4**	**-11.1**	**-22.0**

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Calculation Sheet

CU4 to NSR1

	Octave Band Centre Frequency (Hz)							
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
Noise Source								
Noise Source - CU4								
Noise Levels	**104.0**	**90.5**	**91.0**	**88.0**	**82.0**	**77.5**	**72.5**	**68.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	0.0	*-2.1*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*	*-3.0*
Adiv - Geometrical Divergance								
	-28.1	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*	*-28.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.8*
Agr - Ground Attenuation								
	3.0	*1.3*	*0.9*	*1.4*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-8.3	*-7.0*	*-7.4*	*-9.2*	*-11.0*	*-13.2*	*-15.8*	*-18.5*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**59.6**	**41.6**	**34.4**	**21.1**	**7.4**	**-1.4**	**-9.1**	**-18.0**

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Calculation Sheet

CU5 to NSR2

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU5								
Sound Power Levels	**63.0**	**63.0**	**60.0**	**57.0**	**56.0**	**51.0**	**45.0**	**37.0**
Noise Control Treatments								
Treatment - LE1								
	-4.0	*-4.0*	*-5.0*	*-8.0*	*-12.0*	*-16.0*	*-15.0*	*-13.0*
Dc - Condenser Directivity								
	2.2	*1.1*	*-0.2*	*-1.6*	*-3.0*	*-3.0*	*-3.0*	*-3.0*
Adiv - Geometrical Divergance								
	-20.5	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.4*
Agr - Ground Attenuation								
	3.0	*1.5*	*1.0*	*1.0*	*1.4*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR2								
Sound Pressure, Lp:	**43.7**	**41.0**	**35.3**	**27.9**	**21.9**	**12.9**	**7.9**	**1.6**

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Calculation Sheet

CU6 to NSR2

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU6								
Sound Power Levels	**63.0**	**63.0**	**60.0**	**57.0**	**56.0**	**51.0**	**45.0**	**37.0**
Noise Control Treatments								
Treatment - LE1								
	-4.0	*-4.0*	*-5.0*	*-8.0*	*-12.0*	*-16.0*	*-15.0*	*-13.0*
Dc - Condenser Directivity								
	2.2	*1.1*	*-0.2*	*-1.6*	*-3.0*	*-3.0*	*-3.0*	*-3.0*
Adiv - Geometrical Divergance								
	-20.5	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*	*-20.5*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.4*
Agr - Ground Attenuation								
	3.0	*1.5*	*1.0*	*1.0*	*1.4*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR2								
Sound Pressure, Lp:	**43.7**	**41.0**	**35.3**	**27.9**	**21.9**	**12.9**	**7.9**	**1.6**

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Calculation Sheet

CU1 to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU1								
Sound Power Levels	**78.0**	**78.0**	**69.0**	**71.0**	**65.0**	**60.0**	**55.0**	**50.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	2.8	*2.2*	*1.6*	*1.0*	*0.4*	*0.2*	*0.2*	*0.2*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	-9.1	*-10.1*	*-11.7*	*-13.7*	*-16.1*	*-18.8*	*-21.6*	*-23.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**32.7**	**29.1**	**11.9**	**2.3**	**-12.8**	**-22.7**	**-30.7**	**-39.0**

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Calculation Sheet

CU2 to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU2								
-	**100.5**	**87.5**	**87.5**	**85.0**	**79.0**	**74.5**	**69.5**	**64.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	2.8	*2.1*	*1.5*	*0.9*	*0.3*	*0.2*	*0.2*	*0.2*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	-9.1	*-10.1*	*-11.7*	*-13.7*	*-16.1*	*-18.8*	*-21.6*	*-23.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**55.1**	**38.5**	**30.3**	**16.2**	**1.1**	**-8.2**	**-16.2**	**-25.0**

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Calculation Sheet

CU3 to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU3								
Noise Levels	**97.0**	**87.5**	**86.0**	**81.0**	**75.5**	**73.5**	**70.5**	**64.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	2.5	*1.8*	*1.2*	*0.6*	*0.2*	*0.2*	*0.2*	*0.2*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	-9.1	*-10.1*	*-11.7*	*-13.7*	*-16.1*	*-18.8*	*-21.6*	*-23.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**51.3**	**38.2**	**28.5**	**11.9**	**-2.4**	**-9.2**	**-15.2**	**-25.0**

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Calculation Sheet

CU4 to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - CU4								
Noise Levels	**104.0**	**90.5**	**91.0**	**88.0**	**82.0**	**77.5**	**72.5**	**68.0**
Noise Control Treatments								
Treatment - AE1								
	-11.0	*-13.0*	*-19.0*	*-28.0*	*-34.0*	*-36.0*	*-36.0*	*-37.0*
Dc - Condenser Directivity								
	2.4	*1.8*	*1.2*	*0.6*	*0.2*	*0.2*	*0.2*	*0.2*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	-9.1	*-10.1*	*-11.7*	*-13.7*	*-16.1*	*-18.8*	*-21.6*	*-23.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**58.3**	**41.2**	**33.5**	**18.9**	**4.1**	**-5.2**	**-13.2**	**-21.0**

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Calculation Sheet

AHU1 Fresh to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Fresh								
Noise Levels	**67.0**	**77.0**	**72.0**	**68.0**	**65.0**	**62.0**	**58.0**	**60.0**
Silencer								
	-5.6	*-10.9*	*-17.4*	*-20.0*	*-19.1*	*-16.8*	*-13.4*	*-12.7*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**27.7**	**35.7**	**24.9**	**17.2**	**13.1**	**10.1**	**8.3**	**10.2**

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Calculation Sheet

AHU1 Supply to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Supply								
Noise Levels	**58.0**	**67.0**	**50.0**	**47.0**	**45.0**	**46.0**	**32.0**	**22.0**
Silencer								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-26.6	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.7*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**28.8**	**41.0**	**24.7**	**20.6**	**16.7**	**15.4**	**0.3**	**-10.2**

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Calculation Sheet

AHU1 Exhaust to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Exhaust								
Noise Levels	**67.0**	**77.0**	**71.0**	**68.0**	**65.0**	**62.0**	**58.0**	**60.0**
Silencer								
	-5.6	*-10.9*	*-17.3*	*-20.0*	*-19.1*	*-16.8*	*-13.4*	*-12.7*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-31.0	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*	*-31.0*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.3*	*-1.2*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**27.7**	**35.7**	**24.0**	**17.2**	**13.1**	**10.1**	**8.3**	**10.2**

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Calculation Sheet

AHU1 Return to NSR3

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Return								
Noise Levels	**58.0**	**67.0**	**50.0**	**47.0**	**45.0**	**46.0**	**32.0**	**21.0**
Silencer								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-26.6	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*	*-26.6*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.7*
Agr - Ground Attenuation								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Abar - Barrier Attenuation								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
External Receiver								
External Receiver - NSR3								
Sound Pressure, Lp:	**28.8**	**41.0**	**24.7**	**20.6**	**16.7**	**15.4**	**0.3**	**-11.1**

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Calculation Sheet

AHU1 Fresh to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Fresh								
Noise Levels	**67.0**	**77.0**	**72.0**	**68.0**	**65.0**	**62.0**	**58.0**	**60.0**
Silencer								
	-5.6	*-10.9*	*-17.4*	*-20.0*	*-19.1*	*-16.8*	*-13.4*	*-12.7*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-35.1	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.5*	*-1.9*
Agr - Ground Attenuation								
	3.0	*1.2*	*-0.1*	*0.9*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-7.9	*-6.2*	*-5.0*	*-6.3*	*-7.5*	*-8.5*	*-10.0*	*-12.0*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**15.8**	**23.6**	**12.7**	**4.6**	**0.0**	**-4.0**	**-7.5**	**-8.0**

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Calculation Sheet

AHU1 Supply to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Supply								
Noise Levels	**58.0**	**67.0**	**50.0**	**47.0**	**45.0**	**46.0**	**32.0**	**22.0**
Silencer								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-35.1	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.5*	*-1.9*
Agr - Ground Attenuation								
	3.0	*1.2*	*-0.1*	*0.9*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-7.9	*-6.2*	*-5.0*	*-6.3*	*-7.5*	*-8.5*	*-10.0*	*-12.0*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**12.4**	**24.5**	**8.1**	**3.6**	**-0.9**	**-3.2**	**-20.0**	**-33.3**

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Calculation Sheet

AHU1 Exhaust to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Exhaust								
Noise Levels	**67.0**	**77.0**	**71.0**	**68.0**	**65.0**	**62.0**	**58.0**	**60.0**
Silencer								
	-5.6	*-10.9*	*-17.3*	*-20.0*	*-19.1*	*-16.8*	*-13.4*	*-12.7*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-35.1	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.5*	*-1.9*
Agr - Ground Attenuation								
	3.0	*1.2*	*-0.1*	*0.9*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-7.9	*-6.2*	*-5.0*	*-6.3*	*-7.5*	*-8.5*	*-10.0*	*-12.0*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**15.8**	**23.6**	**11.8**	**4.6**	**0.0**	**-4.0**	**-7.5**	**-8.0**

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Calculation Sheet

AHU1 Return to NSR1

	Octave Band Centre Frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
Noise Source								
Noise Source - AHU1 Return								
Noise Levels	**58.0**	**67.0**	**50.0**	**47.0**	**45.0**	**46.0**	**32.0**	**21.0**
Silencer								
	0.0	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
End Reflection & Directional Directivity	*-8.7*	*-5.4*	*-4.7*	*-5.8*	*-7.7*	*-9.9*	*-10.9*	*-10.9*
Dc - Reflections & Directivity								
	3.0	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*	*3.0*
Adiv - Geometrical Divergance								
	-35.1	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*	*-35.1*
Aatm - Atmospheric Absorption								
	0.0	*0.0*	*0.0*	*0.0*	*-0.1*	*-0.2*	*-0.5*	*-1.9*
Agr - Ground Attenuation								
	3.0	*1.2*	*-0.1*	*0.9*	*1.5*	*1.5*	*1.5*	*1.5*
Abar - Barrier Attenuation								
	-7.9	*-6.2*	*-5.0*	*-6.3*	*-7.5*	*-8.5*	*-10.0*	*-12.0*
External Receiver								
External Receiver - NSR1								
Sound Pressure, Lp:	**12.4**	**24.5**	**8.1**	**3.6**	**-0.9**	**-3.2**	**-20.0**	**-34.3**

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Appendix B

Noise Control Treatments

Schedule of Noise Control Treatments

Reference	Location	Description	Insertion Losses (dB)							
			63	125	250	500	1k	2k	4k	8k
None		None	0	0	0	0	0	0	0	0
LE1	CU5-6	AL1515	4	4	5	8	12	16	15	13
AE1	CU1-4	Environ Lite Acoustic Enclosure	11	13	19	28	34	36	36	37
ATT1	AHU1 Fresh In and Exhaust	1000H x 1000W x 900L 40% Free Area	6	11	18	26	34	27	21	13

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