



Building Services Noise Commissioning Measurements

Belle Vue Co-op Academy

Manchester

M15 6LR

Stroma Built Environment Ltd.

SBE Ref: OPP-068103 – AC – 2v1

I. Revision History

Revision	Date	Description		
2v1	19/10/2022	First Issue		
		Compiled By	Authorised By	
		Ben Reed MIOA Senior Acoustic Consultant	Tom Chaffer MIOA Principal Acoustic Consultant	

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II. Executive Summary

Stroma Built Environment (SBE) has been appointed to undertake a building services plant noise impact assessment for the new school building of the Belle Vue Co-op development, Manchester.

A desktop assessment of noise impact due to the operation of building services plant associated with both schools has previously been undertaken and summarised in report 'OPP-068103 NC1v2 Belle Vue Co-op Academy - Building Services Noise Impact Assessment'. This report has been issued to Manchester City Council planning team in support of discharge of Planning Condition 19, part a.

The report calculates noise rating levels at identified noise sensitive receptors (NSR) based on manufacturers noise data for all sources of building services plant in line with the methodology set out in BS 4142. The report sets out calculations to demonstrate that the noise rating level for building services plant is at least 5 dB below the site representative sound level during daytime periods. The report concludes that building services plant meets a BS 4142 assessment of 'low noise impact' and meets the requirements of part a of Planning Condition 19 set out by Manchester City Council.

To validate the above report, further site measurements of installed and commissioned building services noise have been undertaken.

Based on previous site visits, it was anticipated that noise measurements would likely be affected by road traffic and potentially other noise sources, as measurements to inform the assessment were undertaken in the evening period between 19:45 and 20:30.

Building services plant noise associated with the development was not audible at any NSR during the assessment.

A BS 4142 assessment has been undertaken based on site noise measurements. The assessment indicates that operational noise from plant is at least 5 dB below the background sound level during the daytime at all NSRs.

From the results of the assessment in combination with the subjective assessment of plant inaudibility it is concluded that building services plant associated with the development meets the requirements of Planning Condition 19.

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1. Introduction

- 1.1 Stroma Built Environment (SBE) has been appointed by Sir Robert McAlpine to provide acoustic consultancy services relating to fixed external plant servicing the new school building of the Belle Vue Co-op development, Manchester for the purposes of determining compliance with Planning Condition 19.
- 1.2 The purpose of this assessment is to assess the noise impact of new sources of building services plant equipment associated with the development upon the existing noise climate at the nearest noise sensitive receptors (NSR).
- 1.3 A desktop assessment of noise impact due to operation of building services plant associated with the building has previously been undertaken and summarised in report '*OPP-068103 NC1v2 Belle Vue Co-op Academy - Building Services Noise Impact Assessment*'. The report calculates noise rating levels at identified NSRs based on manufacturers noise data for all sources of building services plant in line with the methodology set out in BS 4142. The report sets out calculations to demonstrate that the noise rating level for building services plant is at least 5 dB below the site representative sound level during both daytime and night time periods. The report concludes that building services plant meets a BS 4142 assessment of 'low noise impact' and meets the requirements of the first part of Planning Condition 19 set out by Manchester City Council.
- 1.4 The second part of Condition 19 requires that verification measurements be undertaken of installed and commissioned building services plant on site along with a subjective assessment on noise impact by a suitably qualified acoustic consultant. Condition 19 is set out in full in Section 3 of this report.
- 1.5 This document has been prepared for the sole use, benefit and information of Sir Robert McAlpine for the purposes set out in the document or instructions commissioning the works. The liability of SBE in respect of the information contained herein will not extend to any third party.
- 1.6 This report is limited to addressing the specific acoustic issues contained herein and is based on information and drawings provided by the Client.
- 1.7 Whilst every effort has been made to ensure that this report is easy to understand, it is technical in nature. A glossary of terminology is included in Appendix III.

2. Site Baseline Conditions

- 2.1 The proposed development is located within the Belle Vue area east of the city centre and is situated off Hyde Road A57. The site is bound by a large bingo centre to the east, Belle Vue Speedway stadium to the south, residential dwellings to the west and residential/commercial buildings to the north. The wider area surrounding the site primarily consists of residential/commercial buildings, with the Hope Valley train line approximately 420 m to the west.
- 2.2 The nearest NSRs to the development have been identified as residential dwellings off Hyde Road (north of the site), Ellen Wilkinson Crescent (west of the site), and Bracewell Close (west of the site). The NSRs within the wider site context are indicated by yellow icons on Figure 1 and detailed in Table 1.

Table 1: Nearest identified NSRs

NSR	Description	Approximate Distance to Site Boundary
A	Residential Dwellings – Hyde Road	30 m
B	Residential Dwellings – Ellen Wilkinson Crescent	45 m
C	Residential Dwellings – Bracewell Close	20 m



Figure 1: Site location and nearest identified NSRs

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- 2.3 The development's fixed terminating/external plant comprises numerous heat recovery units (HRU), air handling units (AHU), hybrid ventilation units (HVV) and extract fans.
- 2.4 A baseline noise survey was undertaken by BDP on the 3rd November 2020 in order to determine prevailing background noise levels at the site and nearby NSRs. Relevant extracts from the BDP report detailing the noise survey results used to inform the assessment, as well as measurement positions and the survey methodology, is provided in Appendix II.

3. Noise Assessment Guidance and Criteria

Planning Requirements

- 3.1 Planning consent for the development was granted under application 129076/VO/2021, subject to conditions. Condition 19 relates to control of building services noise and is reproduced on Figure 2 below.

19) a) Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5dB (LAeq) below the typical background (LA90) level at the nearest noise sensitive location. Prior to commencement of the use hereby approved the scheme shall be submitted to and approved in writing by the City Council as local planning authority in order to secure a reduction in the level of noise emanating from the site.

b) Prior to occupation of the development a verification report shall be submitted to and approved in writing by the City Council as local planning authority to validate that the work undertaken throughout the development conforms to the recommendations and requirements in the approved acoustic report. The report shall also undertake post completion testing to confirm that the noise criteria have been met. Any instances of nonconformity with the recommendations in the report shall be detailed along with any measures required to ensure compliance with the agreed noise criteria.

Figure 2: Planning condition 19

- 3.2 Based on measured background noise survey data, total emission levels for plant noise, including acoustic feature corrections where applicable, should not exceed the maximum rating level values provided in Table 2.

Table 2: Maximum plant noise limits

NSR Location	Approx. distance from site boundary	Daytime (07:00 – 23:00)		Night-time (23:00 – 07:00)	
		Representative background noise level dB $L_{A90,T}$	BREEAM PoI 05 Rating Level dB $L_{Ar,Tr}$	Representative background noise level dB $L_{A90,T}$	BREEAM PoI 05 Rating Level dB $L_{Ar,Tr}$
A	30 m	57	52	(see note 1)	(see note 1)
B	45 m	47	42	(see note 1)	(see note 1)
C	20 m	47	42	(see note 1)	(see note 1)

¹ BDP have assumed that the plant associated with the scheme will only be operational during the typical hours of operation (i.e. daytime) and have only proposed daytime (07:00 – 23:00 hours) BS 4142 rating noise limits. Therefore, only the day-time period has been assessed. If the proposed development plant were to be operational during the night-time period (23:00 – 07:00 hours), the criteria would need to be revised.

BS 4142:2014 + A1:2019: 'Methods for rating and assessing industrial and commercial sound'

- 3.3 BS 4142 describes a method for assessing the likelihood of complaints from noise sources that are of an industrial nature (e.g. fans, pumps, chillers, air handling units etc.). The assessment methodology is based upon determining a 'rating level' for the equipment being assessed, which is the level of noise from the item or items of plant being assessed (measured as L_{Aeq}).
- 3.4 The rating level is then compared with the underlying background noise level (measured as L_{A90}) in the absence of noise from the item or items of plant being assessed.
- A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
 - A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.
 - 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.
- 3.5 BS 4142 states that a penalty should be added for any plant which gives rise to noise features that may increase disturbance such as tonal, impulsive or intermittent characteristics. With respect to the acoustic feature correction, BS 4142 states:
- "Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level."*
- 3.6 A rating penalty for a sound may be based on a subjective assessment of its characteristics or using objective methods to determine tonality.

4. Noise Impact Assessment

- 4.1 A desktop assessment of noise impact due to operation of building services plant associated with the building has previously been undertaken and summarised in report '*OPP-068103 NC1v2 Belle Vue Co-op Academy - Building Services Noise Impact Assessment*'. This report has been issued to Manchester City Council planning team in support of discharge of Planning Condition 19, part a.
- 4.2 The report calculates noise rating levels at identified NSR based on manufacturers noise data for all sources of building services plant in line with the methodology set out in BS 4142. The report sets out calculations to demonstrate that the noise rating level for building services plant is at least 5 dB below the site representative sound level during both daytime and night time periods. The report concludes that building services plant meets the requirements of Condition 19, part a as set out by Manchester City Council.
- 4.3 Part b of Condition 19 requires that verification measurements are undertaken to ensure that the above noise levels at receptors are met. Based on SBE's previous experience of similar projects and the practical difficulty in obtaining these measurements a subjective assessment of plant noise by an acoustic consultant to supplement on site measurements is considered suitable to aid assessment which has been acceptable to Manchester City Council on previous projects.
- 4.4 Building services plant are understood to operate during school hours only and will not operate during the night time, as such assessment during the daytime period (07:00-23:00) only has been considered.
- 4.5 SBE attended site on 17th October 2022 in order to undertake an assessment of plant noise. Based on previous site visits, it was anticipated that noise measurements would likely be affected by road traffic and potentially other noise sources, as measurements to inform the assessment were undertaken in the evening period between 19:45 and 20:30 to minimise these effects as far as practicable.
- 4.6 Measurements were undertaken at the location of each of the identified receptors around the site identified in Figure 1.
- 4.7 Noise levels were measured using UKAS calibrated NTi XL2 precision integrating sound level meter. Calibration checks were carried out both before and after the measurements with no significant variance observed. Calibration certificates are available on request. Weather conditions during the survey were dry with wind speeds of less than 5 ms⁻¹. The sound level meter was mounted on a tripod at an approximate height of 1.5 metres and fitted with a proprietary outdoor microphone kit.
- 4.8 Comparative site measurements with plant on and off are summarised in Table 3.

Table 3: Summary of commissioning measurements

Measurement Location	Plant Operation	Start Time	Measurement Duration	Measured Sound Pressure Level	
				dB $L_{Aeq,T}$	dB L_{A90}
NSR A	On	19:47	00:04:05	67	53
	Off	20:27	00:04:42	66	55
NSR B	On	20:07	00:04:14	46	44
	Off	20:13	00:02:58	47	44
NSR C	On	19:58	00:03:30	48	45
	Off	20:20	00:03:15	46	45

- 4.9 The noise climate at the time of measurements was controlled primarily by local and distant traffic noise with some noise from pedestrians and rustling trees.
- 4.10 BS4142:2014 states that where the difference between the ambient sound level and residual sound level is ≤ 3 dB, which is the case here, then the specific sound level should be determined by calculation.
- 4.11 Given the steady state nature of the plant and comparatively transient nature of road traffic noise, it is considered suitable to base the assessment with reference to the background sound level. Building services plant noise associated with the building was not audible at any measurement position during the assessment. This subjective assessment of inaudibility implies that the specific noise level of plant is at least 10 dB below the existing background noise level. As such the assessment has been based on noise levels which are 10 dB below the background noise levels for each location.
- 4.12 BS 4142 presents a method to assess the 'specific' noise due to a noise source from comparison of measurements with and without the sound source in operation. An assessment based on the BS 4142 methodology is outlined in Table 4. It is not possible to calculate a rating level in accordance with BS 4142 as the residual noise levels (with plant off) are equal to or higher than the ambient noise levels (with plant on). This is an indication that the specific plant noise level does not increase the ambient noise level, and hence it is concluded that the specific plant noise level is at least 10 dB below the measured ambient noise level. The rating level has been calculated by comparison of the background $L_{A90,T}$ measurements with both plant operational and not in operation. Due to the noise climate around the site being heavily influenced by traffic noise, it is considered that the L_{A90} parameter provides a better assessment of steady state underlying plant noise. An example BS 4142 assessment calculation is provided in Appendix I.

Table 4: Summary of BS 4142 Assessments

NSR	Assessment period	Assessed BS 4142 Rating Level $L_{A,r,T,r}$ (dB)	Representative background noise level (dB $L_{A90,T}$)	Difference
NSR A	Daytime (07:00-23:00)	≤ 43	57	-14
NSR B	Daytime (07:00-23:00)	≤ 34	47	-13
NSR C	Daytime (07:00-23:00)	≤ 35	47	-12

4.13 The results of the BS 4142 assessment indicate that the plant noise rating level at the identified NSRs is at least 5 dB below the representative pre-construction background noise levels for daytime periods. This is a low noise impact in line with BS 4142 assessment, and it is considered that the requirements of part b of Condition 19 are met.

5. Conclusions

- 5.1 A plant noise impact assessment has been undertaken for external building services plant associated with the of the Belle Vue Co-op development, Manchester. The assessment is based on site measurements undertaken on 17th October 2022.
- 5.2 A desktop assessment of noise impact due to the operation of building services plant associated with both schools has previously been undertaken and summarised in report '*OPP-068103 NC1v2 Belle Vue Co-op Academy - Building Services Noise Impact Assessment*'. This report has been issued to Manchester City Council planning team in support of discharge of Planning Condition 19, part a.
- 5.3 The report calculates noise rating levels at identified NSRs based on manufacturers noise data for all sources of building services plant in line with the methodology set out in BS 4142. The report sets out calculations to demonstrate that the noise rating level for building services plant is at least 5 dB below the site representative sound level during both daytime and night time periods. The report concludes that building services plant meets the requirements of part a of Condition 19 set out by Manchester City Council.
- 5.4 Based on previous site visits, it was anticipated that noise measurements would likely be affected by road traffic and potentially other noise sources, as measurements to inform the assessment were undertaken in the evening period between 19:45 and 20:30.
- 5.5 Building services plant noise associated with the new school building was not audible at any NSR position during the assessment.
- 5.6 A BS 4142 assessment has been undertaken based on site noise measurements. The assessment indicates that operational noise from plant is at least 5 dB below the background sound level during the daytime at all NSRs.
- 5.7 From the results of the assessment in combination with the subjective assessment of plant inaudibility it is concluded that building services plant associated with the new school building meets the requirements of Planning Condition 19.

Appendix I. BS 4142 Assessments

NSR A (Residential Dwellings – Hyde Road)

Measured ambient sound level	$L_{Aeq,T} = 67$ dB	Plant on
Residual sound level	$L_{Aeq,T} = 66$ dB	Plant off
Representative Background sound level	$L_{A90,T} = 57$ dB	Pre construction background level
Specific sound level at measurement position	$L_{Aeq,T} = 43$ dB	Calculated from background sound level (-10 dB)
BS 4142 Rating level	$L_{Ar,Tr} = 43$ dB	No corrections are applied for tonality, impulsivity or other sound characteristics
Excess of rating over background sound level	-14 dB	Indication that specific noise source does not have an adverse impact

NSR B (Residential Dwellings – Ellen Wilkinson Crescent)

Measured ambient sound level	$L_{Aeq,T} = 46$ dB	Plant on
Residual sound level	$L_{Aeq,T} = 47$ dB	Plant off
Representative Background sound level	$L_{A90,T} = 47$ dB	Pre construction background level
Specific sound level at measurement position	$L_{Aeq,T} = 34$ dB	Calculated from background sound level (-10 dB)
BS 4142 Rating level	$L_{Ar,Tr} = 34$ dB	No corrections are applied for tonality, impulsivity or other sound characteristics
Excess of rating over background sound level	-13 dB	Indication that specific noise source does not have an adverse impact

NSR C (Residential Dwellings – Bracewell Close)

Measured ambient sound level	$L_{Aeq,T} = 48$ dB	Plant on
Residual sound level	$L_{Aeq,T} = 46$ dB	Plant off
Representative Background sound level	$L_{A90,T} = 47$ dB	Pre construction background level
Specific sound level at measurement position	$L_{Aeq,T} = 35$ dB	Calculated from background sound level (-10 dB)
BS 4142 Rating level	$L_{Ar,Tr} = 35$ dB	No corrections are applied for tonality, impulsivity or other sound characteristics
Excess of rating over background sound level	-12 dB	Indication that specific noise source does not have an adverse impact

Appendix II. BDP Noise Survey

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4 Environmental Noise Survey

An environmental noise survey has been undertaken on the 3rd November 2020 at various positions on and in the vicinity of the proposed site.

The data obtained has been used in order to assist in the following:

- Establishing the baseline pre-development noise climate at the site;
- Informing a 3D acoustic noise model of the site for the purposes of assessment of the required sound insulation of the building fabric, including glazing and ventilation; and
- Establishing noise limit criteria for external noise emissions associated with the project from noise associated with the use of the outdoor MUGA pitches as well as noise associated with external plant equipment associated with the development.

4.1 Survey Methodology

A series of manned short-term measurements were undertaken during 'worst-case' daytime and night-time periods. The approximate site boundary & measurement positions are presented in Figure 1 and were selected in order to:

- Measure worst-case, i.e. noisiest, daytime (0800 – 1000 hours) noise levels in order to inform a 3D noise model of the site used to establish the required sound insulation of the building fabric, including glazing and ventilation (Positions 1 – 4);
- Provide data representative of the worst-case, i.e. quietest, daytime (1000 – 1100 hours) noise levels at the nearest or most exposed residential noise sensitive receptors for the purposes of informing external noise emission limits to maintain residential amenity (Positions A – B).

Weather conditions during the survey were dry with low wind speeds varying below 2m/s in a westerly direction, temperatures varying around 6°C and cloud cover of approximately 70%.

The instrumentation used for measurements consisted of 1no. B&K 2260 sound level meter which was calibrated prior to commencing and upon completion of the survey, with no significant drift in sensitivity observed.

At each position octave band and A-weighted fast response levels were recorded for a comprehensive suite of noise level metrics. All readings were taken at a height of 1.5m above local ground level in free-field conditions. Measurements were carried out by Gavin Stevenson MIOA.

Figure 1: Approximate survey measurement positions (red line shows approximate site boundary)



4.1.1 On-Site Noise Climate

The ambient noise climate at the site is dominated by road traffic noise primarily from vehicles travelling on Hyde Road and Kirkmanshulme Lane.

The background noise climate at the site is dominated by distant road traffic noise, primarily from the south-west of the site.

Other noise sources contributing to the ambient noise climate on site included noise from people in the local area, as well as low level noise from the MUGA pitches located to the south of the proposed development site.

It is noted that the speedway stadium to the south of the proposed site does not have the necessary permissions to operate for speedway during typical school opening hours (weekdays); other associated mixed-use external games/sports areas are not expected to cause an increase to the surveyed levels at the proposed development site based on a review of the submitted noise reports associated with the speedway complex's prior planning application.

4.1.2 Results

A summary of the measured results are presented in Table 7 table below.

Table 7: Summary of noise measurement results

Measurement Position	Start Time (hh:mm)	Duration (mm:ss)	$L_{Aeq,5mins}$ Range (dB)	$L_{AFmax,5mins}$ Range (dB)	$L_{A90,5mins}$ Range (dB)
1	08:00	10:00	62 - 63	74 - 76	49
1	09:00	10:00	64 - 65	77 - 80	50
2	08:15	10:00	67	76	55 - 56
2	09:15	10:00	66 - 67	75	57
3	08:28	10:00	51 - 52	64 - 66	49
3	09:27	10:00	51	60 - 67	49
4	08:40	10:00	52 - 54	56 - 62	51 - 52
4	09:40	10:00	53 - 54	59 - 60	51 - 52
A	10:05	15:00	70 - 71	81 - 83	57 - 58
B	10:24	15:00	48 - 49	55 - 59	47

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10 Building Services

10.1 Internal building services noise

Building service items and associated attenuation measures should be selected to ensure compliance with the BB93 IANL criteria.

The table below presents recommended building services noise upper limits to allow the BB93 IANL criteria to be achieved when considering the cumulative noise level of building services noise and other external noise sources (e.g. road traffic), and the BB93 mechanical services noise limits.

The upper limits are presented in terms of $L_{Aeq,T}$ dB and NR levels; both criteria should be complied with when operating at duties to satisfy the BB93 defined 'normal' operation. The limits provided are cumulative and any selection should take account of the total number of noise sources within the space (e.g. inlet, outlet, case, number of units, etc.); these limits should be refined in the subsequent design stages as the external envelope build-ups and associated performance are developed.

Table 14: Preliminary room-side building services noise limits

Room Type	Recommended building services noise limits to achieve the IANL criteria, $L_{Aeq, 20min}$ dB	Recommended building services NR limits to achieve the IANL criteria
General Classrooms	35	29
Offices, Staff workrooms, Meeting/Conference room, Interview room	40	34
Student Support	30	24
Intervention spaces	35	29
Kitchen	50	44
Science Labs, Res Materials, Food Tech, Product Design, Art, ICT, Library, resource/breakout areas	40	34
Main Hall, Drama	35	29
Sports Hall, Activity Studio	40	34
Music: Recording, practice, classroom	35	29
Circulation spaces, corridors, stairwells	45	39
Toilets	50	44
Changing Rooms	50	44
Dining Room	45	39

10.2 Equipment noise levels

General comments on equipment selections with regard to noise levels are provided below:

- Primary attenuators should be incorporated into ductwork near to plant. This helps to reduce airborne noise transmission to the building to an acceptable level.
- In-room units located within occupied spaces will need to be carefully selected to ensure internal noise requirements are achieved. As well as in-line attenuation, it is important to recognise that the units may also need acoustic cladding / boxing in order to control the level of break-out noise from the unit casing. The requirement for this will be dependent on final unit selections.

It should be noted that the internal building services noise limits provided in are cumulative room-side limits, i.e. accounting for all sources of building services noise in the space (case radiated/breakout noise, and down-duct inlet & outlet noise).

10.3 External plant noise emission limits

10.3.1 Plant noise limits at nearest noise sensitive receptors

External plant noise emissions associated with the development should be suitably controlled in order to maintain residential amenity at nearby noise sensitive receptors.

It is assumed that the plant associated with the scheme will only be operational during the typical hours of operation (i.e. daytime), therefore only daytime (0700 – 2300 hours) BS4142 rating noise limits have been proposed below. If the proposed development plant were to be operational during the defined BS4142 night-time period (2300 – 0700 hours), the criteria would need to be revised.

On this basis, the following cumulative noise limits are proposed for fixed items of plant associated with the development, in line with the Local Authority's understood criteria.

Table 15: Preliminary external plant noise emission limits

Noise sensitive receptor	Measured representative Background level, $L_{A90,T}$ (dB)	Cumulative Plant Noise Rating Level Limit at façade of NSR property, $L_{Aeq,T}$ (dB)
Residential dwellings to the north-east of the proposed development site off Hyde Road	57	52
Residential dwellings to the west of the proposed development site off Ellen Wilkinson Crescent and Bracewell Close	47	42

It should be noted that the plant noise limits provided are for the cumulative BS 4142 rating level of all items of plant, and allowance should be made for the number and character of the noise sources. Plant noise should also be controlled sufficiently to ensure that the indoor ambient noise level design criteria for the proposed development are not exceeded.

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Appendix III. Acoustic Glossary

Sound pressure level and the decibel, dB

A sound wave is a small fluctuation of atmospheric pressure. The human ear responds to these variations in pressure, producing the sensation of hearing. The ear can detect a very wide range of pressure variations. In order to cope with this wide range of pressure variations, a logarithmic scale is used to convert the values into manageable numbers. The decibel is the logarithmic unit used to describe sound (or noise) levels. The usual range of sound pressure levels is from 0 dB (threshold of hearing) to 120 dB (threshold of pain).

Frequency and hertz, Hz

Frequency is a measure of the rate of fluctuation of a sound wave. The unit used is cycles per second, or hertz (Hz). Sometimes large frequency values are written as kilohertz (kHz), where 1 kHz = 1000 Hz. The human range of hearing is commonly accepted to be 20 Hz to 20,000 Hz. Additionally, an octave can be used to describe the interval between a frequency in Hz and either half or double that frequency.

Frequency weighting

Different weighting networks can be applied to a given sound level in each stated octave band by a specified amount, in order to better represent the response of the human ear. The most commonly used weighting network is the 'A' weighting, and the letter 'A' will be included within a descriptor to indicate that the value has been 'A' weighted, e.g. $L_{Aeq,T}$ or L_{A90} . An 'A' weighted noise level may also be written as dB(A). Other weightings less commonly used are 'C' and 'D' weighting.

Noise indices

When a noise level varies with time, the measured 'A' weighted dB level will vary as well. In this case it is therefore not possible to represent the noise climate with a simple 'A' weighted dB value. In order to describe noise where the level is continuously varying, a number of other indices, including statistical parameters, are used. The various indices used are described as below:

$L_{Aeq,T}$	The 'A' weighted 'equivalent continuous noise level' which is an average of the total sound energy measured over a specified time period, T
L_{Amax}	The maximum 'A' weighted noise level that was recorded during the monitoring period.
L_{A10}	The 'A' weighted noise level that was recorded for at least 10% of the monitoring period.
L_{A90}	The 'A' weighted noise level that was recorded for at least 90% of the monitoring period, usually taken as the underlying 'background' noise level.

Sound level difference, D

The sound level difference between two internal spaces, or between internal and external spaces. The ' D ' value is used to denote the differences at each third octave or octave band, with a single figure 'weighted' value to describe an overall performance. Note that the ' D ' value will always describe an in-situ or on-site acoustic performance. All values are described using the decibel.

D_w	Single figure weighted sound level difference, simply the measured source noise level minus receiver noise level, not adjusted to reference conditions
$D_{nT,w}$	Weighted normalised sound level difference – a single, weighted sound insulation value, normalised to a reference reverberation time using the measured reverberation time in the receive room
$D_{nT,w} + C_{tr}$	As above, with a spectral adaptation term applied to account for the effects of low frequency noise, and based on urban traffic noise
$D_{nf,w}$	Overall flanking normalised level difference - A parameter that defines the flanking transmission of sound from room to room where a dividing partition or floor construction abuts a flanking building element common to both rooms, such as the building façade or ceiling

Sound reduction index, R

This describes the sound transmitted through a material or building element, such as a wall, door or window. It is measured in a laboratory with suppressed flanking transmission. The ' R ' value is used to denote the differences at each third octave or octave band, with a single figure 'weighted' value to describe an overall performance. All values are described using the decibel.

R_w	Weighted single figure sound reduction index
$R_w + C_{tr}$	As above, with a spectral adaptation term applied to account for the effects of low frequency noise, and based on urban traffic noise
R'_w	The 'apparent sound reduction index', a field measurement to obtain the sound reduction index of a material or element, with all effects of site installation accepted.

Noise rating, NR

The noise rating or NR system is commonly used in the design of noise emitted by internal building services systems. The system is frequency dependent, and was empirically derived to prevent disturbance to occupants in habitable or working areas from building services noise that exhibits 'tonal' elements, e.g. rumbles, whines, whistles etc. There is no direct relationship between the average 'A' weighted noise level in dB and the NR. However, as a guide, and assuming the absence of strong low frequency content in a given noise, the NR could generally be said to be 6 dB less than the average 'A' weighted dB value.

Appendix IV. SBE Acoustic Credentials

SBE have specialised in providing the UK Construction Industry with a range of acoustics services since 2006. Specialising in Building Acoustics, all SBE acousticians are members of the Institute of Acoustics.

SBE has been accredited for on-site acoustic testing by United Kingdom Accreditation Service (UKAS) since 2006 (Testing Laboratory Number 2587).

SBE meet the relevant acoustic requirements typically required in the UK, including for sound insulation testing as defined in Approved Document E for the purposes of testing for Part E to the Building Regulations 2010.

This report has been prepared by Ben Reed, Senior Acoustic Consultant who meets the BREEAM requirements for a suitably qualified acoustician (SQA) as follows:

1. Holds an BEng (Hons) Acoustics degree.
2. Has been an Acoustic Consultant since August 2014 and therefore has more than three year's relevant experience (within the last five years). This experience includes a practical understanding of factors affecting acoustics in relation to construction and the built environment; including, acting in an advisory capacity to provide recommendations for suitable acoustic performance levels and mitigation measures.
3. Holds Corporate Membership of the Institute of Acoustics - MIOA membership.

This report has been read and reviewed and has been found to:

1. Represent sound industry practice.
2. Be appropriate given the building being assessed and scope of works proposed.
3. Avoid invalid, biased and exaggerated recommendations

Appendix V. Report Conditions

This document has been prepared for the sole use, benefit and information of the Client. The liability of Stroma Built Environment Ltd. in respect of the information contained herein will not extend to any third party unless prior agreement is obtained in writing from Stroma Built Environment Ltd.

This report is limited to addressing the specific acoustic issues contained herein. Advice has been provided for acoustic reasons only and it is recommended that appropriate expert advice be sought on all the ramifications, e.g. safety, fire, structural, CDM etc., associated with any proposals contained herein.

The in-situ performance of acoustic measures is influenced to a large extent by the quality of workmanship and compliance with the specifications on-site during construction, as such, Stroma Built Environment Ltd. accepts no liability for issues with acoustic performance arising from such factors.

Acoustic survey and testing work carried out for the project is representative of the prevailing conditions at the time of the work. Conditions can vary and no warranty is given as to the possibility of changes in the environment of the site and surrounding area at differing times.

In particular, it should be noted that where calculations are carried out that are based on assumptions regarding certain aspects where information has not been supplied, these are provided for indicative purposes only and should be treated as such.