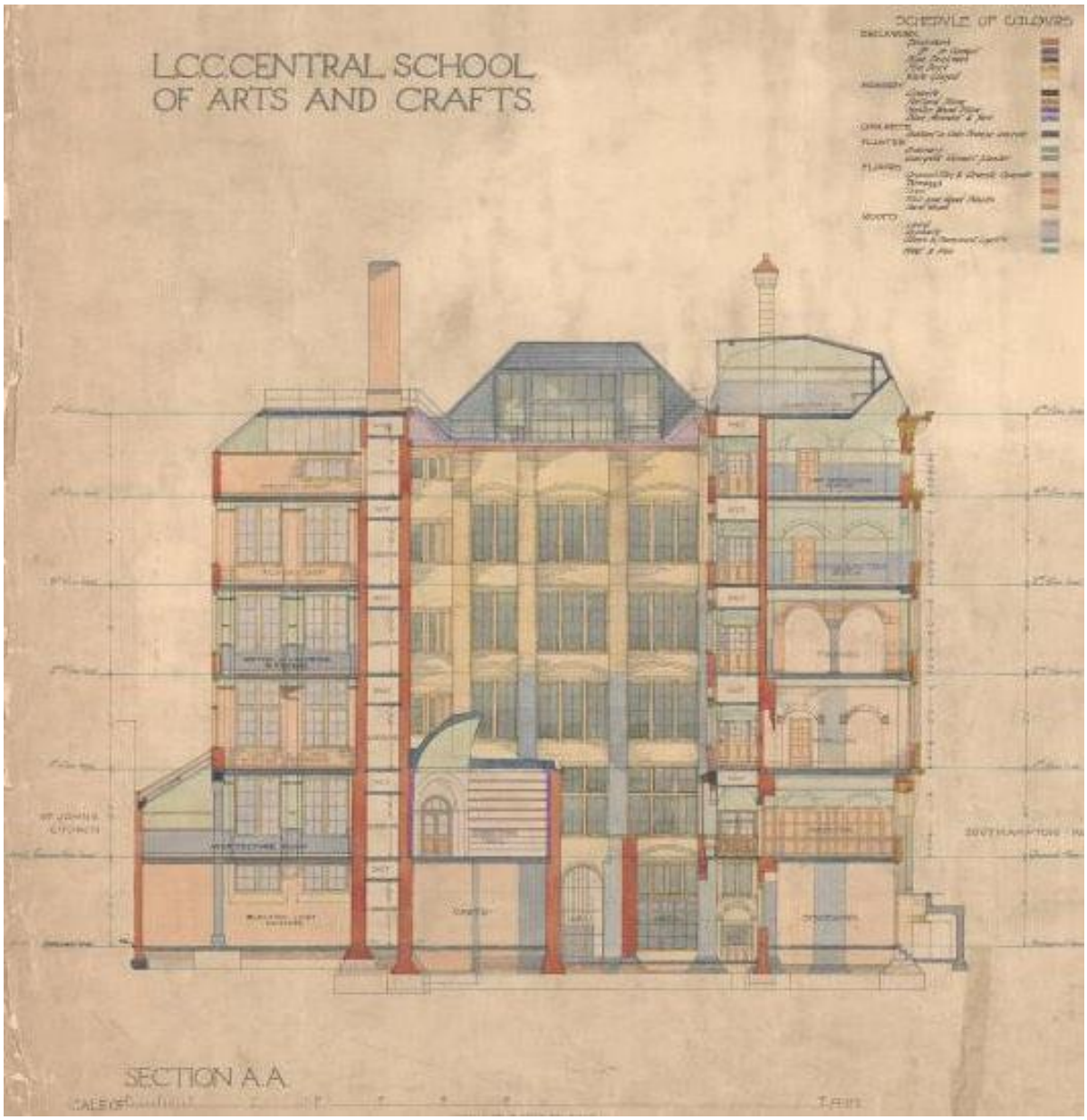
CAHILL DESIGN CONSULTANTS
FIRE ENGINEERING | ACOUSTIC DESIGN

Project

Former CSM Site, Holborn

Title

Noise Assessment Report for Planning



Notice

This document and its contents have been prepared and are intended solely for Globalgrange Limited information in relation to the proposed hospitality and residential development at Southampton Row, Holborn, London, WC1B 4AR. Cahill Design Consultants Limited assumes no responsibility to any other party in respect of, or arising out of, or in connection with this document and/or its contents.

This document has 43 pages including the cover.

Document history

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1. Introduction & Overview

1.1. Cahill Design Consultants (CDC) has been commissioned by Globalgrange Limited, to provide acoustic consultancy services to the proposed mix-use development located at Southampton Row, Holborn, London, WC1B 4AR.

1.2. The proposed development involves refurbishment of the existing Lethaby building to accommodate a boutique hotel, and part demolition of the existing building previously used by University of Arts London (currently named Theobolds Building), to accommodate a new hotel and new residential development. The ground floor proposes a range of use classes including cultural, retail, restaurant and office.The Red Lion Building will also incorporate a new build extension to increase the height of this building.

1.3. As part of the proposed development, three basement levels are proposed to be excavated, which will incorporate conferencing facilities and leisure space. The basement will be largely located beneath the existing Red Lion Building.

1.4. The proposed site falls under the jurisdiction of London Borough of Camden (LBC) and is bounded by Drake Street (and Red Lion Square) to the east, Southampton Row to the west, Theobolds Road to the north and Fisher Street to the south.

1.5. In addition, the Piccadilly Underground Line runs along the west elevation and Crossrail runs along the south elevation of the development site.

1.6. The site boundaries of the proposed development are shown in yellow in below figure.

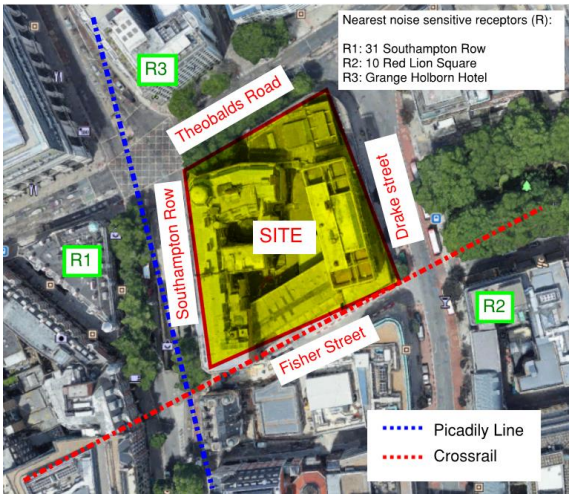


Figure 1 Proposed development site (highlighted in yellow colour)

1.7. An assessment has been undertaken based on the results of the environmental noise and vibration surveys undertaken in December and January 2020 to establish the existing noise climate across the site. The survey results have been used to assess the suitability of the site for mixed use development in accordance with relevant criteria.

1.8. For the details of the survey, please see environmental noise survey report issued in February 2019 (P1185 Southampton Row, Holborn - Environmental Noise & Vibration Survey report).

1.9. This Acoustic Report presents the proposed acoustic strategy for the development, encompassing proposed criteria and methodology, noise and vibration survey details and acoustic strategy for the design and construction phases of the development.

1.10. This report also outlines the requirements for planning with respect to noise and vibration during the construction and operational phases of the project.

1.11. A glossary for acoustic terminology can be found in Appendix A.

2. Policy & Guidance Documents

National & Local Policy and Guidance

2.1. Noise Policy Statement for England, 2010 (NPSE)

2.2. The Noise Policy Statement for England (NPSE) applies to all forms of noise including environmental noise, neighbour noise and neighbourhood noise but does not apply to noise in the workplace. The Government recognises that the effective management of noise requires a co-ordinated and long term approach that encompasses many aspects of modern society.

2.3. The long term vision of Government noise policy is set out to promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

2.4. This long term vision is supported by three aims:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life.

2.5. The NPSE introduces the concept of NOEL, LOAEL and SOAELs, which are described below:

- NOEL – No Observed Effect Level – This is the level below which no observable effect can be detected.
- LOAEL – Lowest Observed Adverse Effect Level – This is the level above which adverse effects on health and quality of life can be detected.
- SOAEL – Significant Observed Adverse Effect Level - This is the level above which significant effects on health and quality of life can be detected.

Planning Policy Guidance – Noise, 2014

2.6. This guidance is provided online within the UK Government Planning System.

2.7. The guidance expands upon the concepts of Observed Effect Levels and the following table is provided.

Table 1 Planning Policy Guidance – Noise exposure hierarchy

Perception	Examples of Outcomes	Increasing Effect Level	Outcome
Not Noticeable	No Effect	No Observable Effect	No Specific Measured Required
Noticeable but not Intrusive	Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area, but not such that there is a perceived change in the quality of life.	No Observed Adverse Effect	No specific measures required.
		Lowest Observed Adverse Effect Level	
Noticeable and Intrusive	Noise can be heard and causes small changes in behaviour and/or attitude, eg turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and Reduce to a Minimum
		Significant Observed Adverse Effect Level	
Noticeable and disruptive	The noise causes a material change in behaviour and/or attitude, eg avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Noticeable and very disruptive	Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, eg regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, eg auditory and non-auditory	Unacceptable Adverse Effect	Prevent

2.8. The guidance further states:

- *In cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur.*
- *If external amenity spaces are an intrinsic part of the overall design, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended.*
- *The potential effect of a new residential development being located close to an existing business that gives rise to noise should be carefully considered. This is because existing noise levels from the business even if intermittent (for example, a live music venue) may be regarded as unacceptable by the new residents and subject to enforcement action. To help avoid such instances, appropriate mitigation should be considered, including optimising the sound insulation provided by the new development's building envelope. In the case of an established business, the policy set out in paragraph 182 of the Framework should be followed.*

National Planning Policy Framework, 2019 (NPPF)

2.9. The National Planning Policy Framework (NPPF) includes the following statements relating to noise and the requirement to take it into account in the planning process.

2.10. Section 15, 170 (e) states:

- *preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability.*

2.11. Section 16, 180 states

- (a) *mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life.*
- (b) *identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason;*

2.12. Paragraph 182 of NPPF further elaborates on the consideration of existing businesses, as follows:

- *Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed.*

2.13. The NPPF does not provide absolute limits on noise that are acceptable or unacceptable in a given situation. It does, however, set out the "need to ensure that developments do not give rise to significant adverse impacts on health and the quality of life". In addition, the

operations of existing businesses are also protected, with reference to ensuring new developments do not have an adverse effect on their operations.

The Environmental Protection Act 1990

2.14. Under Part III of the Environmental Protection Act 1990 as amended by the Noise and Statutory Nuisance Act 1993, local authorities have a duty to investigate noise complaints relating to a variety of sources, excluding road traffic noise. If the local authority is satisfied that the noise amounts to a statutory nuisance it will serve an Abatement Notice which may require that the noise be stopped altogether or limited to certain times.

2.15. Under this Act, the premises responsible for an alleged noise statutory may employ the following as Best Practicable Means (BPM) for defence against an abatement notice:

- 'Practicable' means reasonably practicable, having regard among other things to local conditions and circumstances, to the current state of technical knowledge and to the financial implications;
- the means to be employed include the design, installation, maintenance and manner and periods of operation of plant and machinery, and the design, construction and maintenance of buildings and structures;
- the test is to apply only so far as compatible with any duty imposed by law;
- the test is to apply only so far as compatible with safety and safe working conditions, and with the exigencies of any emergency or unforeseeable circumstances.

Camden Local Plan 2017

2.16. The Camden Local Plan is the key policy document setting out the Council's planning policies.

2.17. Policy A4 "Noise and Vibration" states the following:

"*Where uses sensitive to noise and vibration are proposed close to an existing source of noise or when development that is likely to generate noise is proposed, the Council will require an acoustic report to accompany the application. Supplementary planning document Camden Planning Guidance on amenity provides further detail of the key information expected to be reported in acoustic reports.*

Camden noise thresholds (see Appendix 3) reflect observed effect levels outlined in National Planning Practice Guidance and will be explained further in the Camden Planning Guidance on amenity supplementary planning document. The thresholds set noise levels for:

- *noise sensitive development in areas of existing noise; and*
- *noise generating development in areas sensitive to noise."*

2.18. Appendix 3 of the document provides internal ambient noise level criteria for noise sensitive premises in line with BS 8233:2014 requirements (please see Table 4) which are explained in further section.

2.19. Appendix 3 of the document also states the following for plant noise emission limits:

"*Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and Camden Local Plan | Appendices 347 commercial sound' (BS 4142) will be used. For such cases a 'Rating Level' of 10 dB below background (15dB if tonal components are present) should be considered as the design criterion).*"

3. Acoustic Criteria

3.1. It is understood that the project will satisfy following standards and guidance with regards to acoustics which are further explained in following sections:

- Approved Document E of the Building Regulations 'Resistance to the Passage of Sound', 2010 Edition describes the key evaluations to be undertaken to progress the design.
- BS8233:2014 'Guidance on sound insulation and noise reduction for buildings'
- BS 4142: 2014 'Methods for rating and assessing industrial and commercial sound'
- *BS5228-2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise.*
- BS6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings, Part1'

Approved Document E of the Building Regulations 'Resistance to the Passage of Sound', 2010 Edition

3.2. Recommendations for the sound insulation performance of the party walls will be made in accordance with the requirement outlined in the Building Regulations 2010, Approved Document E – Resistance to the passage of sound (2003 edition, amended 2004, 2010, 2013 and 2015). This came into force on the 1st July 2003 with amendments being introduced in subsequent years. This encompasses all relevant standards applicable to the party walls and floors having a separating function, in addition to treatment to common circulation spaces.

3.3. In the case of the proposed development, ADE outlines the requirements for 'Rooms for Residential Purposes' (hotel accommodation). These requirements have been outlined within this report.

3.4. ADE provides the following tables, taken directly from the document, outlining the requirements for sound insulation to party walls and floors.

Table 2 Performance Standards of Approved Document E, 2010, relating to '*Rooms for Residential Purposes*' (Table 0.1b in document)

Table 0.1b **Rooms for residential purposes – performance standards for separating walls, separating floors, and stairs that have a separating function**

	Airborne sound insulation sound insulation $D_{nT,w} + C_{tr}$ dB (Minimum values)	Impact sound insulation $L'_{nT,w}$ dB (Maximum values)
Purpose built rooms for residential purposes		
Walls	43	-
Floors and stairs	45	62
Rooms for residential purposes formed by material change of use		
Walls	43	-
Floors and stairs	43	64

3.5. Similarly, ADE provides the following table, taken directly from the document, outlining the requirements for internal sound insulation.

Table 3 Performance Standards for Internal Walls and Floors within Rooms (Table 0.2 in document)

Table 0.2 **Laboratory values for new internal walls and floors within dwelling-houses, flats and rooms for residential purposes, whether purpose built or formed by material change of use**

	Airborne sound insulation R_w dB (Minimum values)
Walls	40
Floors	40

3.6. ADE also outlines the requirements for reverberation control within common areas of the buildings. These would include common corridors, hallways, stairwells, entrance halls and would apply to both hotel accommodation and residential units.

3.7. The areas requiring acoustic treatment are defined within ADE as follows:

- "Corridors, hallways, stairwells and entrance halls, that give access to…… rooms for residential purposes"

3.8. ADE provides two methods for the control of reverberation in the above defined areas. These areas:

- **Method A** – Cover a specified area with an absorber of an appropriate class, that has been rated according to BS EN ISO 11654:1997 Acoustics. '*Sound absorbers in buildings. Rating of absorption'*.

- **Method B** – Determine the minimum amount of absorptive material using a calculation procedure in octave bands. Method B is only intended for corridors, hallways and entrance halls as it is not well suited to stairwells.

3.9. The above different methods are further defined within this report

BS8233:2014 'Guidance on sound insulation and noise reduction for buildings'

3.10. This standard provides information and guidance on sound insulation and noise reduction for buildings. It deals with the control of external noise and outlines recommendations for occupied rooms. These levels would apply to both residential accommodation and guest rooms. The following table shows required indoor ambient to be achieved within habitable rooms.

Table 4 Indoor Ambient Noise Levels for Dwellings (ref. BS8233:2014)

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living Room	35dB $L_{Aeq,16Hr}$	-
Dining	Dining Room/Area	40dB $L_{Aeq,16Hr}$	-
Sleeping	Bedroom	35dB $L_{Aeq,16Hr}$	30dB $L_{Aeq,8Hr}$

3.11. The noise levels presented are based on existing WHO guideline values. The document further recommends that guideline value may be set in terms of SEL or $L_{Amax,F}$, depending on the character and number of events per night. Sporadic noise events could require separate values. In this instance a target value of 45 dB L_{Amax} has been established as the average L_{Amax} level not to be exceeded in bedrooms at night.

3.12. It should be noted regarding section 7.7.2 of BS8233:2014, the 45dB L_{Amax} limit only applies to night periods.

3.13. BS8233 also offers recommendations for the control of noise to external amenity areas. This would apply to balconies, gardens, courtyards or other private or communal external spaces.

3.14. The recommendation is for noise levels within these areas not to exceed 50-55 dB L_{Aeq}, with 55 dB being described as the upper guideline value for environments exposed to higher levels of noise.

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

3.15. BS 4142:2014 describes methods for determining and assessing noise levels from noise sources with a view to determining the likelihood of adverse impact.

3.16. The document has been developed for the purposes of:

- Investigating complaints,
- Assessing sound from proposed new, modified or additional sources of sound of an industrial and / or commercial nature; and
- Assessing sound at proposed new dwellings or premises used for residential purposes.

3.17. The document is now suitable for the determination of noise nuisance. Furthermore, that standard is not intended to apply to the following sources of noise:

- Recreational activities, including all forms of motorsport;
- Music or other entertainment;
- Shooting grounds;
- Construction and demolition;
- Domestic animals;
- People;
- Public address systems for speech;
- Other sources falling within the scopes of other standards or guidance.

3.18. The methodology requires the determination of the specific sound level, corrected for characteristic feature in order to produce a rating level. The rating level is then compared against the background noise level (expressed as $L_{A90,T}$), thereby producing an 'excess of Rating over background sound level' figure. This figure is then used for assessment of likelihood of adverse impact.

3.19. The standard places great emphasis on the context of the sound environment that is being assessed and the development overall. This is an essential part of the assessment process, particularly when predicting likelihood of adverse impact. However, for guidance the following is included in the standard:

- Typically, the greater the difference, the greater the magnitude of the impact;
- 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 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. When 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.

BS6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings, Part1'

3.20. BS6472-1:2008 '*Guide to evaluation of human exposure to vibration in buildings, Part1: Vibration sources other than blasting*', offers guidance on vibration in buildings. While the guidelines are intended for residential buildings, the values offer a useful guideline for the design of other building uses also. The following table is taken from the document and outlines acceptable levels of vibration, expressed as VDVs.

Table 5 VDV values referenced in BS6472:2008

Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings

Place and time	Low probability of adverse comment $m \cdot s^{-1.75}$ 1)	Adverse comment possible $m \cdot s^{-1.75}$	Adverse comment probable $m \cdot s^{-1.75}$ 2)
Residential buildings 16 h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

3.21. As a vibration threshold target, the vibration levels within the building, should not exceed 0.1 $ms^{-1.75}$, within residential accommodation. This level is applicable to residential use only to allow appropriate sleeping / resting conditions. A Commercial / Retail use would have a higher threshold than the outlined 0.1 $ms^{-1.75}$, as defined for residential buildings. Therefore, the recommended criteria for Commercial use if 0.4 $ms^{-1.75}$.

3.22. Achieving the above levels within the accommodation will ensure that a 'Low Probability of Adverse Comment' is achieved, in accordance with BS6472.

3.23. As airborne or structure borne noise was determined to be a potential issue, this element has been considered also.

BS5228-2009+A1:2014 Code of practice for noise and vibration control on construction and open sites – Noise

3.24. There are no statutory limits regarding construction noise. BS5228-1:2009+A1:2014 '*Code of practice for noise and vibration control on construction and open site – Part 1: Noise*', provides guidance on assessing the potential significance of noise effects from construction activities in Annex E. Within the guidance there are two approaches described for threshold limits and noise level changes.

3.25. The following table has been reproduced from table E.1 in BS5228-1:2009+A1:2014 and shows the 'ABC criteria' thresholds for potential significant effect.

3.26. The ambient noise level is determined through baseline noise survey at, or within the vicinity of, the nearest residential properties and then rounded to the nearest 5dB to determine the appropriate category (A, B or C) and subsequent threshold value. This is compared with the noise level predicted from construction activity. A potential significant effect is indicated if the construction noise level exceeds the appropriate category threshold value.

3.27. If the existing ambient level exceeds the threshold category threshold values, then a potential significant impact is indicated if the total noise level, including both the ambient noise and the various contributions of construction noise, is greater than the ambient noise level by more than 3dB.

Table 6 Construction Activity Noise Levels: Example Threshold of Potential Significant Effect at Dwellings (BS5228-1:2009+A1:2014)

Assessment Category and Threshold Value Period	Threshold Value in decibels (dB) ($L_{Aeq,T}$)		
	Category A [A]	Category B [B]	Category C [C]
Night-Time (23:00 – 07:00)	45	50	55
Evenings and Weekends [D]	55	60	65
Daytime (07:00 – 19:00) and Saturdays (07:00 – 13:00)	65	70	75
NOTE 1: A potential significant effect is indicated if the total $L_{Aeq,T}$ noise level arising from the site exceeds the threshold level for the Category appropriate to the ambient noise level.			
NOTE 2: If the ambient noise level exceeds the threshold values given in the table (i.e. the ambient noise level is higher than the above values), then a potential significant effect is indicated if the total $L_{Aeq,T}$ noise level for the period increases by more than 3dB due to site noise.			
NOTE 3: Applied to residential receptors only.			
A) Category A: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are less than these values.			
B) Category B: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are the same as category A values.			
C) Category C: threshold values to use when ambient noise levels (when rounded to the nearest 5dB) are higher than category A values.			
D) 19:00 – 23:00 Weekdays, 13:00 – 23:00 Saturdays and 07:00 – 23:00 Sundays.			

Department for Transport Memorandum, Calculation of Road Traffic Noise, 1988

3.28. The Department for Transport Memorandum, Calculation of Road Traffic Noise provides methods for measuring and calculating noise levels from road traffic, which is assessed over an 18 hour period from 06:00 to 24:00, using annual average weekday traffic (AAWT) flows. The basic noise level for a road segment can be calculated using the traffic flow, traffic speed and percentage heavy vehicles for a road segment. The traffic data will be based on the construction methods that are to be employed and information from the traffic assessment (TA).

Design Manual for Roads and Bridges part 11:3:7

3.29. The advice note entitled 'Design Manual for Roads and Bridges, Volume 11, Section 3, Part 7 HD 213/11 Noise and Vibration' dated 2011 provides guidance on the assessment of the impacts that road projects may have on levels of noise and vibration. Where appropriate, this advice may be applied to existing roads.

3.30. It provides guidance on the significance of changes in road traffic noise, identifying that changes in noise smaller than 1 dBA are not perceptible in the short term. Assuming no changes to percentage

composition of heavy goods vehicles or traffic speeds, an increase in traffic volume of 25% is required to alter the noise levels by 1 dBA.

3.31. The advice note gives an example classification of magnitude of impacts for opening year road traffic noise impacts, as shown in Table 7:

Table 7 DMRB Noise Changes and Magnitude of Opening Year Impacts

Noise change, $L_{A10,18h}$	Magnitude of Impact
0	No change
0.1 – 0.9	Negligible
1 – 2.9	Minor
3 – 4.9	Moderate
5+	Major

3.32. Although advice is given on the magnitude of impacts, no specific guidance is provided on the significance of the effect of these changes.

4. Environmental Noise Survey

Survey Methodology

4.1. Unattended noise measurements were undertaken at free-field and facade locations at the site boundaries of the proposed development to establish the existing noise climate.

4.2. The details of the noise measurement positions (NMP) are summarised below:

- NMP1 (Theobalds Road): microphone located on the north boundary of the proposed development, on a tripod approximately 1.5 m above surface level, on a roof overlooking Theobalds Road. Measurements were undertaken from Friday 25 January 2019 until Tuesday 29 January 2019.

- NMP2 (Southampton Row): microphone located on the west boundary of the proposed development (within existing Lethaby building) on a pole minimum 1.0 m away from the first-floor facade of Lethaby building overlooking Southampton Row. Measurements were undertaken from Tuesday 15th January 2019 until Monday 21st January 2019.

- NMP3 (Drake Street): microphone located on the east boundary of the proposed development on a tripod approximately 1.5 m above surface level, on a roof overlooking Drake Street. Measurements were undertaken from Thursday 6th December 2018 until Monday 10th December 2018.

- NMP4 (Fisher street): microphone located on the south boundary of the proposed development on a tripod approximately 1.5 m above surface level, on a roof overlooking Fisher Street. Measurements were undertaken from Thursday 20th December 2018 until Monday 24th December 2018.

4.3. Environmental noise survey locations are presented in Appendix B of this report.

Equipment

4.4. A Rion NL52 sound level meter, and a Rion NC74 calibrator have been used for the surveys. The details of the equipment used for the survey are presented in below table. The sound level meter was calibrated no more than two years prior, and the calibrator was calibrated no more than one year prior to the surveys, by an accredited laboratory.

4.5. Acoustic measurement equipment used during the survey conforms to relevant British Standards, namely BS EN 61672 and BS EN 60942.

4.6. The calibration certificates of the equipment can be found in Appendix D.

Table 8 Equipment used for the environmental noise survey

Equipment	Manufacturer	Type	Serial Number
Sound Level Meter	Rion	NL52	01043459
Microphone	Rion	UC59	07235
Calibrator	Rion	NC74	35246905

4.7. Environmental survey data was measured in accordance with BS7445-1:2003 'Description and measurement of environmental noise'.

4.8. The microphones were fitted with windshields throughout the surveys, and the sound level meters were calibrated before and after all the surveys with no significant deviation noted.

4.9. All measurements were undertaken over representative weekday and weekend periods, and sound level meters were set to record the L_{Aeq}, L_{AFmax}, and L_{AF90} indices at sufficiently fine resolution.

Meteorological Conditions

4.10. Meteorological conditions were noted during the noise surveys.

4.11. Weather conditions were generally conducive to environmental noise survey with light winds. However, there were periods of rain at various times as well as periods where the wind speed had numerous amounts of rises above the recommended 5 m/s during the measurements. The measured data at these times have been removed. Therefore, the measured data reported in this document are appropriate to be used in assessments.

Results Summary

4.12. The following tables provide a summary of the daytime (07:00 to 23:00) and night time (23:00 to 07:00) measurement results for:

- Equivalent continuous noise levels derived by logarithmically averaging the consecutive data measured during daytime ($L_{Aeq,16h}$) and night-time ($L_{Aeq,8h}$) periods,
- The daytime and night-time minimum background noise levels ($L_{A90,15min}$), and
- Night-time typical maximum noise levels (L_{AFmax}) which is derived by calculating the 90th percentile of the measured 15-minute L_{AFmax} levels during the respective period.

Table 9 Measured free-field daytime noise levels at each noise measurement position (NMP)

Measurement Locations	Daytime (07:00 to 23:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
NMP1 –Theobalds Road	67	57	92
*NMP2 – Southampton Row	70	56	97
NMP3 – Drake Street	63	51	86
NMP4 – Fisher Street	61	51	83

** -2 dB facade correction has been applied to the measured noise levels.*

Table 10 Measured free-field night-time noise levels at each noise measurement position

Measurement Locations	Night Time (23:00 to 07:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
NMP1 –Theobalds Road	65	53	91
*NMP2 – Southampton Row	68	53	95
NMP3 – Drake Street	61	48	84
NMP4 – Fisher Street	58	48	81

** -2 dB facade correction has been applied to the measured noise levels.*

5. Vibration Survey

Survey Methodology

5.1. An internal vibration survey was undertaken between 18th and 25th January 2019, with both Crossrail and Piccadilly underground trains in operation underneath the survey site location. The vibration meter was set up at basement level within the existing Lethaby Building.

5.2. Measurements were undertaken using a Menhir vibration meter, S/N V16210200.

5.3. Measurements were undertaken with and without Crossrail services in operation to provide a baseline for assessment, prior to Crossrail being developed.

5.4. It is understood that Crossrail carriages were in operation (testing) between Sun 20th January 2019 24:00hrs to Thurs 24th January 2019 24:00hrs, running at normal line speed.

5.5. It is understood that both the Piccadilly Line and Crossrail were operating over 24 hours daily during the measurement period. The Piccadilly Line trains passed this location on a regular occurrence, understood the be every 2 minutes. The exact movements for Crossrail at this location, was not confirmed at the time of writing.

5.6. A plan showing the site and the Vibration Monitoring Position 1 (VMP1) is shown in Appendix B of this document. The measurement equipment was setup internally at basement level, within an existing gymnasium in the south west corner of the space. This is the closest location to both the Piccadilly Line and Crossrail.

5.7. The measurement location within the gymnasium comprised of a hard-stone floor, where the vibration monitor was sited.

Equipment

5.8. Vibration equipment used during the survey conforms to standard DIN 45669-1:2010-09.

5.9. Simultaneous measurements were undertaken on all three axis, X, Y and Z.

5.10. A summary of the equipment used is outlined in the following table.

Table 11 Equipment used for the vibration survey

Equipment	Manufacturer	Type	Serial Number
Vibration Meter	SEMEX-EngCon Gmbh	Menhir	16210200

Vibration Survey Results

5.11. Tables illustrated below show the summary of one-minute measurements undertaken at the measurement location over a representative period during each day and night for when Crossrail was both operational and not operational. The Piccadilly Line was operational during all measurements.

Table 12 Results of measurements when Crossrail is not in operation

Period	Date	Measurement	VDV X axis ($m/s^{1.75}$)	VDV Y axis ($m/s^{1.75}$)	VDV Z axis ($m/s^{1.75}$)
Daytime	18 January 2019	Minimum	0.0003	0.0003	0.0028
		Maximum	0.0235	0.0041	0.0245
		Arithmetic Average	0.0016	0.0013	0.0115
	19 January 2019	Minimum	0.0003	0.0003	0.0024
		Maximum	0.0041	0.0032	0.0251
		Arithmetic Average	0.0003	0.0003	0.0024
Night-time	18 January 2019	Minimum	0.0002	0.0002	0.0016
		Maximum	0.0039	0.0030	0.0232
		Arithmetic Average	0.0008	0.0007	0.0078
	25 January 2019	Minimum	0.0002	0.0002	0.0018
		Maximum	0.0040	0.0029	0.0235
		Arithmetic Average	0.0006	0.0006	0.0068

Table 13 Results of measurements when Crossrail is in operation

Period	Date	Measurement	VDV X axis ($m/s^{1.75}$)	VDV Y axis ($m/s^{1.75}$)	VDV Z axis ($m/s^{1.75}$)
Daytime	20 January 2019	Minimum	0.0002	0.0003	0.0024
		Maximum	0.0040	0.0032	0.0240
		Arithmetic Average	0.0012	0.0010	0.0097
	21 January 2019	Minimum	0.0003	0.0003	0.0027
		Maximum	0.0044	0.0030	0.0248
		Arithmetic Average	0.0016	0.0013	0.0115
	22 January 2019	Minimum	0.0003	0.0003	0.0033
		Maximum	0.0041	0.0031	0.0246
		Arithmetic Average	0.0015	0.0012	0.0110
	23 January 2019	Minimum	0.0003	0.0003	0.0030
		Maximum	0.0042	0.0032	0.0234
		Arithmetic Average	0.0015	0.0013	0.0113
	24 January 2019	Minimum	0.0003	0.0004	0.0031
		Maximum	0.0042	0.0032	0.0238
		Arithmetic Average	0.0015	0.0012	0.0110
Night-time	20 January 2019	Minimum	0.0002	0.0002	0.0017
		Maximum	0.0037	0.0030	0.0217
		Arithmetic Average	0.0007	0.0006	0.0071
	21 January 2019	Minimum	0.0001	0.0002	0.0012
		Maximum	0.0037	0.0027	0.0232
		Arithmetic Average	0.0006	0.0005	0.0067
	23 January 2019	Minimum	0.0002	0.0002	0.0017
		Maximum	0.0041	0.0030	0.0213
		Arithmetic Average	0.0006	0.0006	0.0070
	24 January 2019	Minimum	0.0003	0.0004	0.0041
		Maximum	0.0037	0.0029	0.0232
		Arithmetic Average	0.0014	0.0011	0.0108

6. Construction Noise Assessment

Construction Overview

6.1. The redevelopment of the Lethaby Building will comprise the internal refurbishment and layout changes to all floors of the building. The existing Red Lion Building will be part demolished to leave the structural shell of the Building only. New build floors will be added to the existing building. In addition, a new build residential building(Theobalds Building) will be developed to the north of the site.

6.2. A three storey basement level will be excavated directly below the Red Lion Building and the Theobalds building.

6.3. It is assumed that all works will be undertaken under a Section 61 Agreement and best practicable means (BPM), will be engaged to ensure that noise and vibration from the excavation, demolition and construction works, is appropriately managed and controlled.

6.4. A construction schedule has been issued for the development. This information has been considered in the development of this report. Please refer to the Construction Management Plan for further information.

Construction Traffic

6.5. It is currently anticipated that construction equipment and materials will be stored on site, where possible. This will assist with reducing the number of trips from construction vehicles to and from the site.

6.6. At this time there is no formal schedule for the number of construction vehicles that will arrive at the site on a daily basis, however, the daily numbers are expected to be low in comparison to the overall traffic in the area, particularly the main routes, Southampton Row and Theobald's Road.

6.7. It is recommended that all construction traffic avoids the minor roads in and around the area, in order to minimise noise increases on quieter roads.

6.8. It is understood that main construction traffic access and exit route will be via Fisher Street. Drake Street will be used as a delivery pit lane to allow for site deliveries and piling operations.

6.9. It is also understood that all construction traffic will arrive during daytime hours and the peak traffic times 8:30 – 9am and 15-15:30 (Monday to Friday) will be avoided. No night-time deliveries will be made. No construction transportation is anticipated to arrive or leave the site during weekends.

6.10. All site visitors and operators will be encouraged to use public transportation, and there will be no parking spaces on site.

6.11. In terms of noise impacts from construction transportation, anything less than a 25% increase in flows equates to a change of less than 1 dB and so is not considered an impact. In this case the predicted flows from construction traffic will be significantly less than 25% and so the impact is considered as 'No Change'.

6.12. Therefore, the impact from construction traffic is expected to be 'No Change'. However, this should be confirmed by the contractor when construction traffic plans are finalised.

Construction Activities

6.13. All construction activities will be undertaken during daytime hours, as defined in BS5228, between 07:00 – 18:00 Monday to Friday and Saturdays between 07:00 – 13:00.

6.14. At the time of writing a detailed construction equipment schedule was not finalised. Therefore, this section outlines the maximum noise levels at receivers, which shall not be exceeded, in order to minimise 'significant' noise and vibration effects from construction activities. This would apply to excavation, demolition and general construction activities.

6.15. Based upon measured ambient levels at the defined noise sensitive receivers (NSRs), the Threshold value for 'significance' has been defined as outlined within the following table, in accordance with BS5228. Predicted construction noise impacts above this Threshold would be deemed a 'significant' impact. For levels predicted to be below the Threshold, impacts are deemed not to be 'significant'.

6.16. These levels relate to 1m from the nearest defined receivers on the referenced roads.

Table 14 Maximum construction noise levels to receivers (ref. BS5228)

Noise Sensitive Receiver (NSR)	Maximum Construction Noise L_{Aeq} (dB) at receiver
Southampton Row Receivers	75
Theobald's Road Receivers	70
Drake Street Receivers	65
Fisher Street Receivers	65

6.17. The above levels shall form part of the Section 61 Agreement for the demolition and construction works.

6.18. It is recommended that construction noise and vibration monitoring is undertaken during the main construction periods, to minimise the risk of damage to adjacent buildings or negative health effects on occupiers of adjacent buildings.

6.19. Considering the above, the construction works, as proposed, do not pose any constraints to the requirements of planning be met, with respect to noise and vibration, providing suitable mitigation provision is implemented during high noise and vibration construction periods.

7. Operational Noise Assessment

Operational Transportation

7.1. Operational transportation relating to the development has been assessed as part of this study. In order to undertake this study, the Traffic Impact Study has been developed with Arup during development of their Transport Assessment.

7.2. The Transport Assessment predicts that the changes between the existing development (largely student and commercial use) and the proposed uses. In terms of transportation modes that generate noise (personal cars, motor-cycles, buses, vans), the proposed development is predicted to increase peak hour trips (AM and PM) by 48.

7.3. A large majority of these are a result of taxi trips, which equate for 44 additional trips. This is slightly offset by a reduction in buses / minibus trips of -11.

7.4. It should be noted that these figures do not include use of the “Events and Conference Venue” spaces located at basement level, which may generate peaks in transportation in the localised area, depending on the scale of event.

7.5. In terms of noise impacts from construction transportation, anything less than a 25% increase in flows equates to a change of less than 1 dB and so is not considered an impact. In this case the predicted flows from operational traffic will be less than 25% and so the impact is considered as ‘No Change’. This excludes exhibition use of the basement area.

Building Services Noise

Overview

7.6. At the time of writing, it is understood that the ventilation strategy will be to employ mechanical systems throughout all areas, where possible to implement. Plant rooms will be strategically located throughout all the buildings including upper floor and basement areas.

7.7. It is understood that roof top plant will also be used.

Internal Acoustic Noise Conditions

7.8. Noise emissions from all mechanical plant equipment into room areas should not exceed the specified NR levels outlined in the Acoustic Strategy Report and drawings. The limits specified for building services noise should include the cumulative noise from all sources of mechanical noise including breakout noise through ductwork and / or equipment casing.

7.9. Noise levels within plant rooms should not exceed the Control of Noise at Work Regulations first action level which is 80 dBA. Within high noise areas, signage should be provided and where the noise levels are expected to exceed 80 dBA, ear protection should be provided.

External Acoustic Noise Conditions

7.10. The planning condition relating to plant noise has been mentioned previously in paragraph 2.19 above.

7.11. In accordance with above and the background noise levels below table sets out the cumulative plant noise emission limits for the development.

Table 15 External Building Services Environmental Noise Emission Limits

Facade	Period	Background Noise	*Building Services Criteria (Non-tonal plant)	*Building Services Criteria (Tonal plant)
Southampton Row	Daytime (07:00 - 23:00 hrs)	56 dB $L_{A90,15min}$	46 dB $L_{Aeq,T}$	41 dB $L_{Aeq,T}$
	Night-time (23:00 – 07:00 hrs)	53 dB $L_{A90,15min}$	43 dB $L_{Aeq,T}$	38 dB $L_{Aeq,T}$
Theobald's Road	Daytime (07:00 - 23:00 hrs)	57 dB $L_{A90,15min}$	47 dB $L_{Aeq,T}$	42 dB $L_{Aeq,T}$
	Night-time (23:00 – 07:00 hrs)	53 dB $L_{A90,15min}$	43 dB $L_{Aeq,T}$	38 dB $L_{Aeq,T}$
Drake Street	Daytime (07:00 - 23:00 hrs)	51 dB $L_{A90,15min}$	41 dB $L_{Aeq,T}$	36 dB $L_{Aeq,T}$
	Night-time (23:00 – 07:00 hrs)	48 dB $L_{A90,15min}$	38 dB $L_{Aeq,T}$	33 dB $L_{Aeq,T}$
Fisher Street	Daytime (07:00 - 23:00 hrs)	51 dB $L_{A90,15min}$	41 dB $L_{Aeq,T}$	36 dB $L_{Aeq,T}$
	Night-time (23:00 – 07:00 hrs)	48 dB $L_{A90,15min}$	38 dB $L_{Aeq,T}$	33 dB $L_{Aeq,T}$

** Maximum free-field level at 1m from the residential window ($L_{Aeq,T}$)*

7.12. The above criterion is based upon the L_{Aeq} levels of he completed development, being a minimum of 10 dB below the pre-development background noise levels (expressed as dB L_{A90}).

7.13. The levels shall be achieved at 1m from the nearest facades of the defined receivers, with all plant operating on normal operating duty, simultaneously.

7.14. Further coordination and recommendation for mitigation, if appropriate, will be developed in coordination with the building services design team throughout the next design stage.

8. Architectural Acoustics

8.1. Acoustic strategy drawings have been developed to inform the proposed design of vertical and horizontal elements.

External Fabric Sound Insulation

8.2. The ventilation strategy will be to employ mechanical systems where possible to implement Therefore, all acoustic assessments undertaken are based upon this strategy.

8.3. Outlined in the following tables are the minimum sound insulation requirements for both external walls and glazing to achieve the indoor ambient noise levels given in Table 4 of this report.

8.4. The external wall specification, both existing and proposed, is assumed at this stage as this information is currently unknown.

Table 16 External Fabric Acoustic Specifications

External Wall Elevation	Proposed Glazing	Assumed External Wall	Trickle Vents
Southampton Row Facade (west)	10mm / 12mm / 11mm (lam) (44 dB R_w)	Exact build up TBC. Assumed to achieve a minimum of 53 dB R_w	N/A
Theobolds Road Facade (north)	6mm / 12mm / 11mm (lam) (40 dB R_w)	Exact build up TBC. Assumed to achieve a minimum of 53 dB R_w	N/A
Drake Street Facade (east)	6mm / 12mm / 11mm (lam) (40 dB R_w)	Exact build up TBC. Assumed to achieve a minimum of 53 dB R_w	N/A
Fisher Street Facade (south)	6mm / 12mm / 11mm (lam) (40 dB R_w)	Exact build up TBC. Assumed to achieve a minimum of 53 dB R_w	N/A

8.5. The glazing performance should be achieved with the complete window system, including framing and seals.

8.6. The outlined specification for external walls and glazing will achieve the requirements of BS8233 and assumed planning conditions.

8.7. Within the existing Lethaby building, the glazing is currently a mix of poorly sealed original single glazing or secondary glazing. These windows will need to be inspected and enhanced if they are to achieve the requirements outlined above. It is very likely to secondary glazing will be required, assuming that the existing glazing has to be retained.

8.8. Comfort cooling during day and night hours via openable windows may be possible on elevations facing away from the main roads. Rooms facing the main roads will exceed the requirements of BS8233 when windows are opened. However, this option should be considered to allow guest / resident comfort. However, it should be accepted that internal noise levels will be exceeded under this scenario.

Structure Borne Noise Control

8.9. As outlined within this report, structure borne noise from the Piccadilly Line affects the Lethaby Building on its south facing Fisher Street facade and to some extent, the west facing Southampton Row facade. Structure borne noise is clearly audible from basement level to 5th floor level on these elevations.

8.10. Based upon the above, it is recommended to isolate the external walls and floors on these facades. This would affect the following elevations, as shown below.

Figure 2 Structure borne noise facades to be treated (red)

8.11. The above walls should be isolated from the structure with rubber or spring Isolators. The typical build up should be as follows:

- Structural external wall
- Minimum 50mm cavity with 25mm insulation 48kg/m^3
- Rubber isolation clip or spring isolator
- 2x15mm high density plasterboard (minimum density 12kg/m^3)

8.12. An example of a rubber isolation clip is shown in the following figure.

Figure 3 Rubber isolation clip example

8.13. In addition to the above , it is recommended that an isolated floating floor system is also introduced to the affected rooms. Details for this will be developed during next design stage, in coordination with the wider design team.

8.14. The underside of the soffits of affected rooms shall also be treated. The above isolating clips creating a minimum 70mm infilled cavity would be sufficient in this instance.

8.15. For initial design purposes, a 75mm allowance should be made for this, subject to further confirmation at the next design stage.

9. CONCLUSIONS

9.1. Cahill Design Consultants has been commissioned by Globalgrange Limited to undertake a noise assessment for planning including an environmental noise survey and a vibration survey for the proposed development at Southampton Row, Holborn, London, WC1B 4AR.

9.2. This report outlines the requirements for the development as the relate to complying with planning guidance, BS8233, BS4142 and other accepted guidance.

9.3. Noise and vibration surveys were undertaken at the proposed development in order to ascertain existing noise levels in and around the development site.

9.4. Construction noise and vibration impacts to nearby receivers have been considered. Maximum limits for noise and vibration levels from construction activities are outlined within this report. It is recommended that noise and vibration monitoring is undertaken to ensure that noise and vibration thresholds are not exceeded.

9.5. An assessment of operational activities relating to the development has also been undertaken. This includes operational transportation, building services noise and events noise from basement exhibition spaces.

9.6. An assessment of operational transportation has been undertaken, with respect to noise impacts as a result of changes. The assessment demonstrates that the impact will be ‘No Change’, when compared to existing use of the site and proposed use. This excludes use of the proposed exhibition space.

9.7. This report outlines maximum noise levels from building services plant to the nearest noise sensitive receivers on each elevation of the buildings.

9.8. Based upon the measurement results, specific advice if offered for the acoustic design of the external fabric of the building, including glazed elements, ventilation and main structural elements.

9.9. Providing the recommendations contained within this repot are introduced, the development will comply with the requirements of both planning and acoustic design guidance.

9.10. Acoustic design proposals for the development will be updated as the design evolves in coordination with the wider design team.

Appendix A: Acoustic Terminology

AIRBORNE SOUND

Sound in the air is generated by a material vibrating which in turn causes air molecules to vibrate and create a sound wave. For example, sound produced by a loudspeaker in a room can be classified as 'airborne' sound.

AIRBORNE SOUND INSULATION

Airborne sound insulation is the ability of a material or room to contain sound within it, or exclude sound from it. This is commonly measured in terms of sound reduction index (in dB) being the ratio of sound transmitted by the material to that incident upon it. Airborne sound insulation can be measured using the procedures set out in BS EN ISO 140-3 and BS EN ISO 140-4.

AMBIENT AND BACKGROUND NOISE LEVEL, $L_{A90,T}$

The A-weighted sound pressure level of non-specific noise in decibels exceeded for 90% of the given time, T.

A - WEIGHTING dB(A)

The sound pressure level determined when using the frequency-weighting network A. The A-weighting network modifies the electrical response of a sound level meter so that the sensitivity of the meter varies with frequency in approximately the same way that the sensitivity of the human hearing system varies with frequency.

The human ear has a non-linear frequency response; it is less sensitive at low and high frequencies and most sensitive in the range 1 to 4 kHz. The A-weighting is applied to measured or calculated sound pressure levels so that these levels correspond more closely to the response of the human ear. A-weighted sound levels are often denoted as dB(A).

DECIBEL

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p) and the associated measurement unit is the decibel (dB). As the decibel is 10times the logarithmic ratio, the laws of logarithmic addition and subtraction apply.

EQUIVALENT CONTINUOUS A-WEIGHTED SOUND PRESSURE LEVEL (L_{Aeq})

Value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval T starting at t1 and ending at t2 and measured in decibels, has the same mean square sound pressure as the sound under consideration whose level varies with time.

FREQUENCY

The rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the Hertz (Hz), which is identical to cycles per second. A thousand hertz is often denoted kHz, eg 2 kHz = 2000 Hz. Human hearing generally ranges approximately from 20 Hz to 20 kHz.

IMPACT SOUND

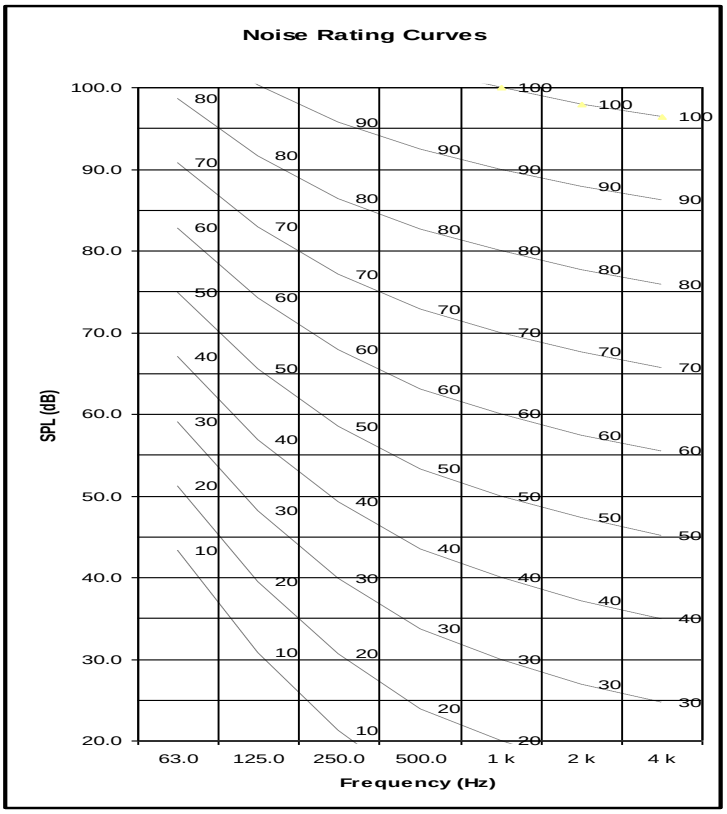
Sound produced by a vibrating material or panel due to direct impact. The vibrating material or panel causes the air molecules to vibrate which leads to an airborne sound wave being created. For example, footsteps on a floor can be classified as 'impact' sound.

IMPACT SOUND INSULATION

Impact sound insulation is the ability of a material to dampen sound. This is commonly determined by measuring the sound pressure level (in dB) on the receiver side of the material being excited by a sound source on the source side. Impact sound insulation can be measured using the procedures set out in BS EN ISO 140-5 and BS EN ISO 140-7.

NOISE RATING CURVES (NR)

A method of expressing noise in a more meaningful way that the standard values in the form of curves as shown below.



The curves represent the human's perception of noise. Less annoyance is caused by low frequency noise than by higher frequency noise at the same sound pressure level. Hence higher levels may be tolerated for low frequency noise. Noise spectra, measured or specified, are often quoted as a NR value for ease of reference.

OCTAVE BANDS AND OCTAVE BAND SOUND PRESSURE LEVEL

The octave-band pressure level of a sound is the band pressure level for a frequency band corresponding to a specified octave. (The location of the octave-band pressure level on a frequency scale is usually denoted by the geometric mean of the upper and lower frequencies of the octave.) The ISO standard octave centre frequencies are 31.5, 63, 125, 250, 500, 1k, 2k, 4k, 8k, 16k Hz (etc.). For design purposes, the octave bands between 63 Hz to 8 kHz are generally used.

PERCENTILE LEVEL (STATISTICAL SOUND LEVEL INDICES, L_{AN}, L_{A90})

L_{AN} is the dB(A) level exceeded N% of the time measured on a sound level meter with Fast(F) time weighting, eg L_{A90} the dB(A) level exceeded for 90% of the time, is commonly used to estimate background noise level. L_{A10}, the dB(A) level exceeded for 10% of the time, is commonly used in the assessment of road traffic noise.

REVERBERATION AND REVERBERATION TIME (RT60)

The time, in seconds, taken for a sound within a space to decay by 60 dB after the sound source has stopped. An important indicator of the subjective acoustic within an auditorium. The symbol T_{mf} to represent the mid-frequency arithmetic average of the reverberation time in the 500 Hz, 1 kHz and 2 kHz octave bands. Reverberation time can be measured using the procedures set out in BS EN ISO 3382. The symbols T20 and T30 are the reverberation times extrapolated from a 20 and 30 dB dynamic

range, starting at the -5 dB point, in order not to introduce errors due to irregularities in the early reflections

SIGNAL-TO-NOISE RATIO (S/N)

This is the difference between the source noise level and the background (or ambient) noise level. The higher the difference, the better the speech intelligibility of the PA/VA system. For PA/VA system announcements, it is preferable to have an S/N ration of at least 15 dB(A) and preferably 25 dB(A) for the hearing impaired.

SOUND ABSORPTION AND SOUND ABSORPTION COEFFICIENT

When sound waves strike a material, some of the sound energy is absorbed and the remaining energy is reflected. The ability of a material to absorb sound is expressed in terms of sound absorption coefficient. The sound absorption coefficient (α) is the percentage of sound absorbed by the material. If a material has α = 0.8 at 500 Hz it means that 80% of the sound is absorbed at this frequency.

Sound absorption can be measured using the procedures set out in BS EN 20354. Single figure descriptors include the practical sound absorption coefficient (α_p) and weighted sound absorption coefficient (α_w) as defined in BS EN ISO 11654. Other commonly used terms (in the USA) are ncC (Noise Reduction Coefficient) which is the arithmetic average of α at 250 Hz, 500 Hz, 1 kHz and 2 kHz rounded to the nearest 5%.

SOUND POWER LEVEL (L_w)

The sound power level of a sound source, in decibels, is 10 times the logarithm to the base 10 of the ratio of sound power radiated by the source to a reference power. The reference power is 1 picowatt (1×10^{-12} watt).

The sound power level is the fundamental measure of the total sound energy radiated by a source per unit time.

SOUND LEVEL DIFFERENCE (D)

The sound insulation required between two spaces may be determined by the sound level difference (D) needed between them. Single figure descriptors include the weighted sound level difference (D_w) and the normalised weighted sound level difference (D_{nTw}) as defined in BS EN ISO 717-1.

SOUND PRESSURE LEVEL (SPL)

The level of the pressure of the sound above the internationally accepted reference value of 20 μPa ($2x10^{-5}$ N/m^2), which corresponds to the pressure of the quietest sound an average person can hear at the frequency of 1000 Hz. It is a quantity that can be measured, thus the quantity of a sound can be derived from it.

A value equal to 10 times the logarithm to the base 10 of the ratio of the root-mean-square pressure of a sound to a reference pressure, which is normally taken to be $2x10^{-5}$ N/m^2.

SOUND REDUCTION INDEX (R)

The sound reduction index, R, (or transmission loss) of a building element is a measure of the loss of sound through the material, ie its attenuation properties. It is a property of the component, unlike the sound level difference which is affected by the common area between the rooms and the acoustic of the receiving room. The weighted sound reduction index, R_w, is a single figure description of sound reduction index which is defined in BS EN ISO 717-1. The R_w is calculated from measurements in an acoustic laboratory. Sound insulation ratings derived from site (which are invariably lower than the laboratory figures) are referred to as the R'_w ratings.

SPEECH TRANSMISSION INDEX (STI)

A physical quantity representing the transmission quality of speech with respect to intelligibility, ie the ability to understand the spoken word.

VIBRATION LEVEL

Vibration is generally measured in terms of the velocity (in mm/s or m/s) or the acceleration (in mm/s^2 or m/s^2) but can also be measured in terms of amplitude (in mm or m). These values are often converted into dB values on a logarithmic scale.

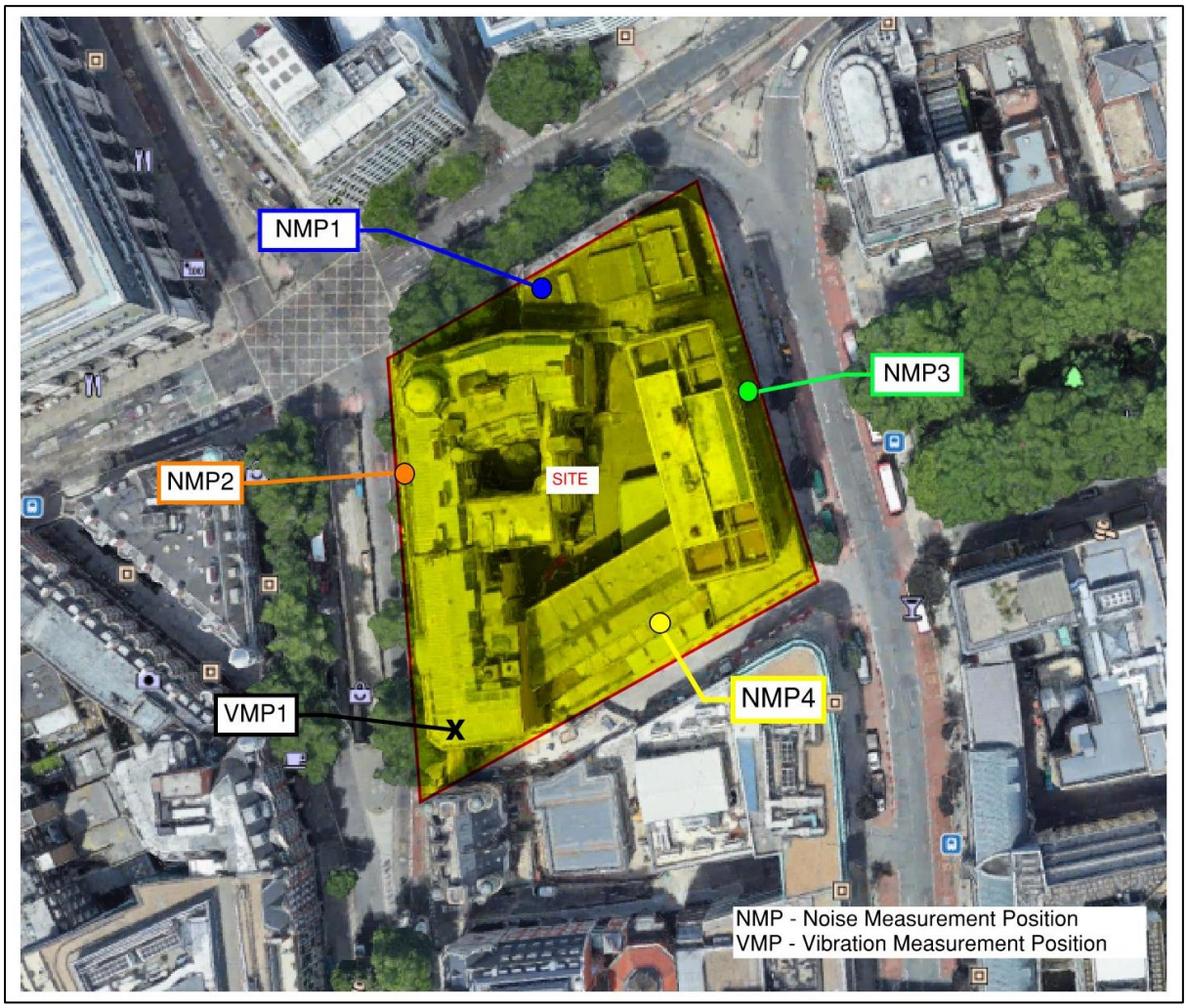
VIBRATION DOSE VALUE (VDV)

A measure of the amount of vibration as experienced by a person. It is a dosage based on both the total exposure time and the vibration acceleration level experienced. Only vibrations in the range of 1 Hz to 80 Hz are considered and these are weighted in accordance with BS 6472.

WEIGHTED SOUND REDUCTION INDEX (R_w)

The weighted sound reduction index, R_w, is a single figure description of sound reduction index which is defined in BS EN ISO 717-1: 1997. The R_w is calculated from measurements in an acoustic laboratory to BS EN ISO 140-3 and rated to BS EN ISO 717-1. Sound insulation ratings derived from site (which are invariably lower than the laboratory figures) are referred to as the R'_w ratings and measured to BS EN ISO 140-4.

APPENDIX B – NOISE AND VIBRATION SURVEY LOCATIONS



APPENDIX C – ENVIRONMENTAL NOISE MEASUREMENT RESULTS

Table C. 1 Measured noise levels at Theobalds Road (NMP1)

Theobalds Road	Day Time (07:00 to 23:00)			Night Time (07:00 to 23:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
*25.01.2019 Friday	67	59	90	65	56	89
26.01.2019 Saturday	66	57	91	67	56	91
27.01.2019 Sunday	65	58	87	63	53	88
28.01.2019 Monday	67	58	92	64	53	84
*29.01.2019 Tuesday	67	58	90	-	-	-

**Friday measurements commenced at 12:24 hrs, and Tuesday measurements ended at 16:24 hrs*

Table C. 2 Measured noise levels at Southampton Row (NMP2)

Southampton Row	Day Time (07:00 to 23:00)			Night Time (07:00 to 23:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
*15.01.2019 Tuesday	72	62	101	70	58	97
16.01.2019 Wednesday	72	62	98	69	59	91
17.01.2019 Thursday	72	62	97	70	58	96
18.01.2019 Friday	72	62	98	71	59	97
19.01.2019 Saturday	71	61	98	71	57	95
*20.01.2019 Sunday	72	58	98	68	55	90

**Tuesday measurements commenced at 12:55 hrs, and Sunday measurements ended at 06:55 hrs*

Table C. 3 Measured noise levels at Drake Street (NMP3)

Drake Street	Day Time (07:00 to 23:00)			Night Time (23:00 to 07:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
06.12.2018 Thursday	64	57	86	61	52	81
07.12.2018 Friday	64	56	86	61	50	84
08.12.2018 Saturday	63	52	82	61	51	83
09.12.2018 Sunday	62	51	85	59	48	82

**Thursday measurements commenced at 12:03 hrs, and Sunday measurements ended at 06:03 hrs*

Table C. 4 Measured noise levels at Fisher Street (NMP4)

Fisher Street	Day Time (07:00 to 23:00)			Night Time (23:00 to 07:00)		
	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB	$L_{Aeq,15mins}$ dB	$L_{A90,15mins}$ dB	$L_{Amax,15mins}$ dB
*20.12.2018 Thursday	64	54	83	59	52	78
21.12.2018 Friday	60	52	83	57	50	78
22.12.2018 Saturday	58	51	79	58	50	82
*23.12.2018 Sunday	58	51	78	56	48	76

**Thursday measurements commenced at 13:01 hrs, and Sunday measurements ended at 08:46 hrs*

APPENDIX D – Calibration Certificates

Campbell Associates Ltd
5b Chelmsford Road Industrial Estate
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Certificate of Calibration and Conformance

CALIBRATION 0789

Certificate No.: U26106

Test object:	**Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision) and associated Frequency Analyser BS EN IEC 61260, Class 1**
Manufacturer:	**Rion**
Type:	**NL52**
Serial no:	**01043459**
Customer:	**Cahill Design Consultants Limited**
Address:	**Creative Business Centre, Studio 201, 37 Queen Street, Colchester, Essex. CO1 2PQ.**
Contact Person:	**Nick Long - Acoustic Engineer**

Method :
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification of sound level meters as set out in BS EN IEC 61672-3:2006 and for electrical testing of frequency filters as set out in BS EN IEC 61260. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

	Producer:	Type:	Serial No:	Certificate number
Microphone	Rion	UC59	07235	26105
Calibrator*	Rion	NC-74	35246905	U26104
Preamplifier	Rion	NH25	43488	Included

Additional items that also have been submitted for verification

Wind shield	Rion	WS10
Attenuator	None	
Extension cable	None	

These items have been taken into account wherever appropriate.

	Pressure:	Temperature:	Relative humidity:
Environmental conditions:			
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	99.91 ± 0.01kPa	21.6 ± 0.2°C	50.8 ± 2%RH

Date received : 07/07/2017
Date of calibration: 19/07/2017
Date of issue: 19/07/2017

Engineer
Palanivel Marappan B.Eng (Hons), M.Sc

Supervisor
Darren Batten Tech IOA

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Certificate of Calibration and Conformance

UKAS Laboratory Number 0789

Certificate No.: U26106

Conformance

From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2002 and similarly that the associated sound calibrator conforms to BS EN IEC 60942.

Statement of conformance

The sound level meter submitted for testing has successfully completed the class 1 periodic tests of BS EN IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available[1], from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with BS EN IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2002, and that the sound level meter submitted for testing conforms to the class 1 requirements of BS EN IEC 61672-1:2003.
The filter functions have been found to conform, by electrical testing, to the relative attenuation requirement of BS EN IEC 61260 (as required by UKAS Lab23) for a class 1 filter over the range of frequencies shown in the attached test report.

[1] This evidence is held on file at the calibration laboratory

Measurement Results:

Indication at the calibration check frequency - IEC61672-3 Ed.1 #9	Passed
Self-generated noise - IEC 61672-3 Ed.1 #10	Passed
Acoustical signal tests of a frequency weighting - IEC 61672-3 Ed.1 #11	Passed
Frequency weightings: A Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: C Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency weightings: Z Network - IEC 61672-3 Ed.1 #12.3	Passed
Frequency and time weightings at 1 kHz IEC 61672-3 Ed.1 #13	Passed
Level linearity on the reference level range - IEC 61672-3 Ed.1 #14	Passed
Toneburst response - IEC 61672-3 Ed.1 #16	Passed
Peak C sound level - IEC 61672-3 Ed.1 #17	Passed
Overload indication - IEC 61672-3 Ed.1 #18	Passed
Filter Test - IEC 61260 1/1octave: Relative attenuation - IEC 61260, #4.4 & #5.3	Passed
Filter Test - IEC 61260 1/3octave: Relative attenuation - IEC 61260, #4.4 & #5.3	Passed
Electrical signal tests of frequency weightings - IEC 61672-3 Ed.1 #12	Passed

Comment

Correct level with associated calibrator is 93.9dB(A).

Observations

No information on the uncertainty of measurement, required by 11.7 of BS EN IEC 61672-3:2006 of the adjustment data given in the instruction manual or obtained from the manufacturer or supplier of the sound level meter, or the manufacturer of the microphone, or the manufacture of the multi-frequency sound calibrator electrostatic actuator was published in the instruction manual or made available by the manufacturer or supplier. The uncertainty of measurement of the adjustment data has therefore been assumed to be numerically zero for the purposes of this periodic test. If these uncertainties are not actually zero, there is a possibility that the frequency response of the sound level meter may not conform to the requirements of BS EN IEC 61672-1:2003.

No adjustment data have been published in the instruction manual or made available by the manufacturer or supplier of the sound level meter to account for the average effects of reflections from the case of the sound level meter and diffraction of sound around the microphone as required by sub-clause 11.4 and 12.6 of BS EN IEC 61672-3:2006. The average effects of reflections from the case of the sound level meter and diffraction of sound around the microphone have therefore been assumed to be numerically zero for the purposes of this periodic test. If these adjustment data are not actually zero, there is a possibility that the frequency response of the sound level meter may not meet the requirements of BS EN IEC 61672-1:2003.

The details of the uncertainty for each measurement is available from the Calibration Laboratory on request and is based on the standard uncertainty multiplied by a coverage factor K=2, providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. Details on the sources of corrections and their associated uncertainties that relate to this verification are contained the detailed test report accompanying this certificate.

K:\C AlCalibration\Mor-1504\Mor-1Init SonCal\2017\Rion\NL62_01040453_M1.doc

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Cert_U61672Ed1_C1_PE_FC1_v1.1

Calibration Report

Certificate No.:26105

Manufacturer: Rion
Type: UC59
Serial no: 07235

Customer: Cahill Design Consultants Limited
Address: Creative Business Centre,
Studio 201, 37 Queen Street,
Colchester, Essex. CO1 2PQ.
Contact Person: Nick Long - Acoustic Engineer

Measurement Results:

	Sensitivity: (dB re 1V/Pa)	Capacitance: (pF)
1:	-26.83	12.5
2:	-26.83	12.5
3:	-26.82	12.5
Result (Average):	**-26.83**	**12.5**
Expanded Uncertainty:	0.10	2.00
Degree of Freedom:	>100	>100
Coverage Factor:	2.00	2.00

The following correction factors have been applied during the measurement:
Pressure:0.000 dB/kPa Temperature:0.000 dB/°C Relative humidity:0.000 dB/%RH

Reference Calibrator: WSCl - Nor1253-24269 Volume correction: 0.000 dB
Records:K:\C A\Calibration\Nor-1504\Nor-1017 MicCal\2017\RIONUC59_07235_M1.nmf
Measurement procedure: TP05
All results quoted are directly traceable to National Physical Laboratory, London

The reported expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k = 2, which for a normal distribution corresponds to coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA publication TA-4/02.

Comment:

Environmental conditions:

Pressure:	Temperature:	Relative humidity:
100.948 ± 0.042 kPa	22.3 ± 0.1 °C	43.8 ± 0.8 %RH

Date of calibration: 18/07/2017
Date of issue: 18/07/2017

Supervisor : Darren Batten TechIOA
Engineer :

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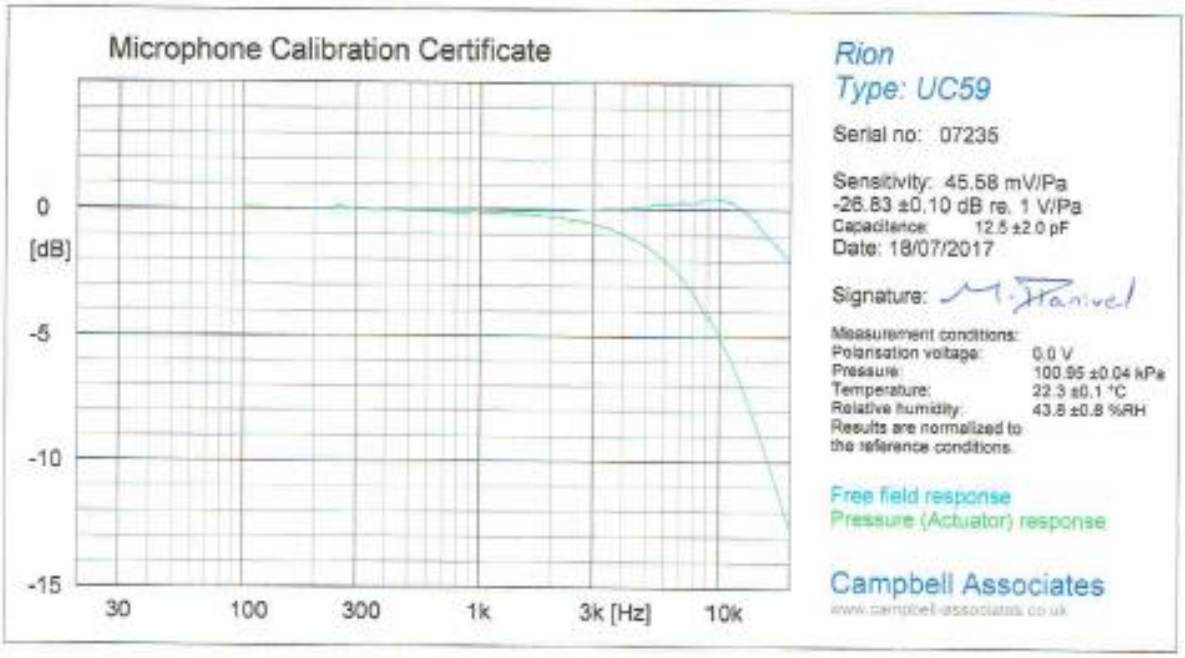
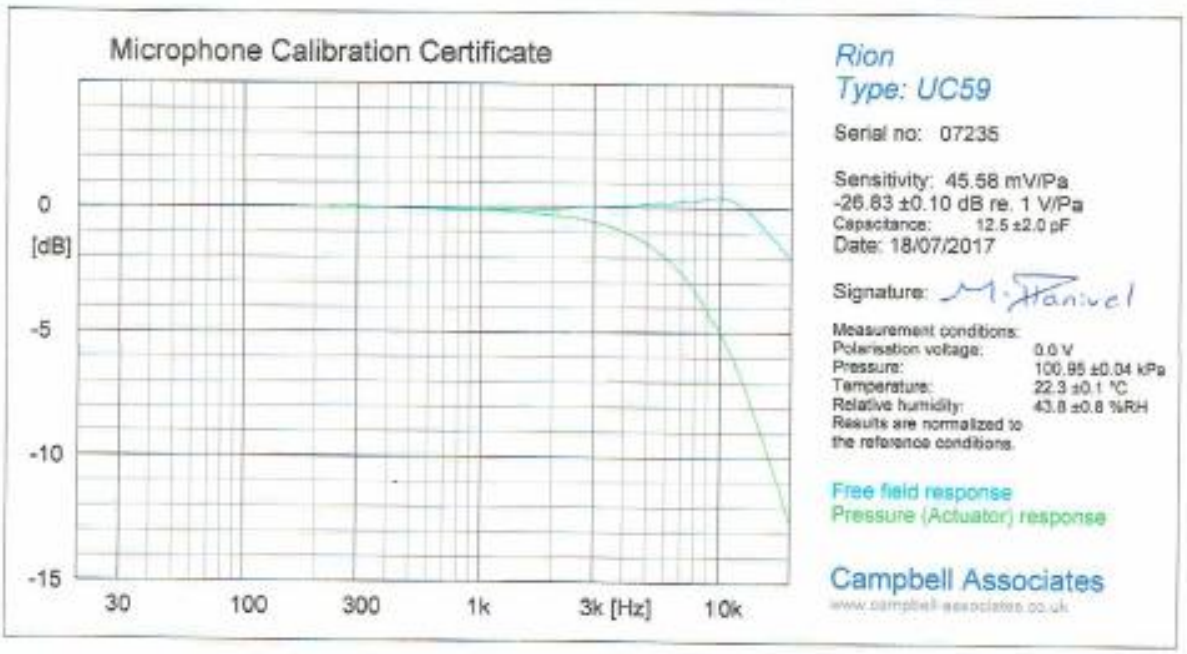
Palanivel Marappan B.Eng (Hons), M.Sc
Software version: 8.0h


Microphone Calibration Certificate
0
[dB]
-5
-10
-15
30
100
300
1k
3k [Hz]
10k
Rion
Type: UC59
Serial no: 07235
Sensitivity: 45.58 mV/Pa
-26.83 ±0.10 dB re. 1 V/Pa
Capacitance: 12.5 ±2.0 pF
Date: 18/07/2017
Signature:
Measurement conditions:
Polarisation voltage: 0.0 V
Pressure: 100.95 ±0.04 kPa
Temperature: 22.3 ±0.1 °C
Relative humidity: 43.8 ±0.8 %RH
Results are normalized to the reference conditions
Free field response
Pressure (Actuator) response
Campbell Associates


Microphone Calibration Certificate
0
[dB]
-5
-10
-15
30
100
300
1k
3k [Hz]
10k
Rion
Type: UC59
Serial no: 07235
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-26.83 ±0.10 dB re. 1 V/Pa
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Temperature: 22.3 ±0.1 °C
Relative humidity: 43.8 ±0.8 %RH
Results are normalized to the reference conditions
Free field response
Pressure (Actuator) response
Campbell Associates

Comment:

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CALIBRATION 0789

Certificate number: U29137

Certificate of Calibration and Conformance

Test object:	**Sound Calibrator**
Manufacturer:	**Rion**
Type:	**NC-74**
Serial no:	**35246905**
Customer:	Cahill Design Consultants Ltd
Address:	Creative Business Centre, Studio 201, 37 Queen Street, Colchester, Essex. CO1 2PQ.
Contact Person:	Nick Long

Measurement Results:	Level	Level Stability	Frequency	Frequency Stability	Distortion
1:	94.09 dB	0.01 dB	1002.29 Hz	0.00 %	1.27 %
2:	94.10 dB	0.01 dB	1002.28 Hz	0.00 %	1.40 %
3:	94.10 dB	0.01 dB	1002.27 Hz	0.00 %	1.33 %
Result (Average):	**94.10 dB**	**0.01 dB**	**1002.28 Hz**	**0.00 %**	**1.33 %**
Expanded Uncertainty:	0.10 dB	0.02 dB	1.00 Hz	0.01 %	0.14 %
Degree of Freedom:	>100	>100	>100	>100	15
Coverage Factor:	2.00	2.00	2.00	2.00	2.28

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions.The following correction factors have been applied during the measurement: Pressure: 0.000 dB/kPa Temperature: 0.000 dB/°C Relative humidity: 0.000 dB/%RH Load volume : -0.00072 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.
Records: K:\C A\Calibration\Nor-1504\Nor-1018 CalCal\2018\RIONNC74_35246905_M1.nmf

	Pressure:	Temperature:	Relative humidity:
Environmental conditions:			
Reference conditions:	101.325 kPa	23.0 °C	50 %RH
Measurement conditions:	100.838 ± 0.041 kPa	21.3 ± 0.1 °C	45.8 ± 1.0 %RH

Date received for calibration:	20/07/2018
Date of calibration:	24/07/2018
Date of issue:	24/07/2018
Engineer	
	Palanivel Marappan B.Eng(Hons), M.Sc
Supervisor	
	Darren Batten TechIOA

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to the units of measurement realised at an accredited national physical laboratory or other recognised standards laboratories. This certificate may not be reproduced other than in full without the prior written approval of the issuing laboratory.

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Template UKAS_PE v2.10 DocR Cert-C0001

Certificate number: U29137

Preconditioning
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to an accredited national physical laboratory within the EU or EFTA.

Comment
Calibrated as received, no adjustments made.

Statement of conformance
As public evidence was available[1], from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

[1] This evidence is held on file at the calibration laboratory.

Notes:
The sound pressure level generated by the calibrator in its ½ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 61094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in **BOLD** are the final results; a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.

Measurements performed by
Campbell Associates

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email calibration@campbell-associates.co.uk
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SEMEX ENGCON

Kalibrierschein (Werkskalibrierung)
Calibration Certificate (Factory Calibration)

16210200-001

1 Kalibriergegenstand/ Calibration Object

Gegenstand/Object:	Schwingungsmesssystem nach / Vibration meter according to DIN 45669
Hersteller/Manufacturer:	SEMEX-EngCon GmbH
Typ/Type:	MENHIR
Serien-Nr./ Serial-No.:	V16210200
Datum/Date:	22.08.2016/Aug. 22, 2016

2 Kalibrierverfahren — Calibration Method

Die Kalibrierung erfolgt nach dem Vergleichsverfahren. Als Referenzsystem dient MENHIR 16210170, das durch die SPEKTRA Schwingungsmesstechnik und Akustik GmbH am 09.08.2016 gemäß DAkkS kalibriert wurde (Kalibrierscheinnummer 2215).	*The calibration process is based on the comparative method of calibration. As a reference, MENHIR 16210170, which has been calibrated on Aug. 09, 2016 (calibration certificate no. 2215) by „SPEKTRA Schwingungsmesstechnik und Akustik GmbH Dresden", a DAkkS accredited independent laboratory.*
Das hier eingesetzte Verfahren beruht auf der Bestimmung der Übertragungsfunktion (Amplitudenfrequenzgang) durch impulsförmige Anregung der Sensoren (mittels geräteinterner aktivierbarer elektrischer Spannung) und der Messung der Impulsantworten. Die Einstellungen der Verstärkung bei 16 Hz, sowie die Parameter des Korrektur-Filters (f, Q) erfolgen über die Geräteeinstellungen, bis die Ziel-Überragungsfunktion gemäß DIN 45669-1:2010-09 erreicht ist. Jeweils vier Impulse (positiv/negativ alternierend) pro Achse werden sequentiell erzeugt und die Übertragungsfunktion durch Mittelung der einzelnen Impulsantworten errechnet. Dieses Verfahren erzeugt die gleichen Ergebnisse auf dem Referenzsystem wie die durch elektrodynamische Schwingerreger ermittelten.	*The applied calibration process is based upon the determination of the transfer function (amplitude spectrum) by applying a sequence of voltage impulses to the sensors (embedded function generator within the device) and measuring the corresponding impulse responses. The calibration parameters (gain @ 16 Hz, correction filter (f, G, Q)) are adjusted until the measured transfer function matches the target transfer function according to DIN 45669-1:2010-09. A sequence of four pulses (alternating positive and negative pulses) per sensor axis is generated and the transfer function is calculated by averaging the individual impulse responses. This method yields the same results as the reference system calibrated by an electrodynamic long stroke shaker.*
Das zu kalibrierende Gerät war mindestens 30 Minuten vor Durchführung der Messungen in Betrieb. Die Umgebungstemperatur betrug 23°C.	*The device under calibration was warmed up for at least 30 minutes prior to calibration. The environmental temperature was measured to 23°C.*

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SEMEX ENGCON

3 Messunsicherheit/ Uncertainty in Measurement

Die relativen Gesamtmessunsicherheiten für die ermittelten Werte betragen: 0,5 Hz bis 1,0 Hz: 1,5% 1,0 Hz bis 63 Hz: 1,0% 63 Hz bis 80 Hz: 1,5% Der Wert der Messgröße liegt mit einer Wahrscheinlichkeit von 95% im zugeordneten Messintervall.	*The relative total measurement uncertainties are determined by:* 0,5 Hz to 1,0 Hz: 1,5% 1,0 Hz to 63 Hz: 1,0% 63 Hz to 80 Hz: 1,5% *The measurement values are with a probability of 95% within the corresponding measurement interval.*

4 Ergebnisse/Results