CONABEARE ACOUSTICS

ACOUSTIC PLANT ASSESSMENT

The Royal Free NHS Trust
Pond Street
Hampstead
London
NW3 2QG

MRI Replacement Project

Reference : CS8160-01
Revision : Revision C
Status : Planning Issue
Issue Date : 25th April 2019

Prepared By:

Stuart Metcalfe

Stuart Metcalfe MIOA

CLIENT:

ROYAL FREE LONDON NHS FOUNDATION TRUST
Pond Street
Hampstead
London
NW3 2QG

NHS
Royal Free London
NHS Foundation Trust

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre, Station Road, Theale, Berkshire. RG7 4AA
Telephone 0118 930 3650 Facsimile 0118 930 3912
sales@conabeare.co.uk

CONABEARE ACOUSTICS

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre, Station Road, Theale, Berkshire. RG7 4AA
Telephone 0118 930 3650 Facsimile 0118 930 3912
sales@conabeare.co.uk

1 Introduction

Conabeare Acoustics Limited have been commissioned by The Royal Free London NHS Foundation Trust to undertake an Acoustic Survey and BS4142:2014 assessment in relation to noise emissions of proposed plant at The Royal Free London Hospital, Pond Street, Hampstead, London NW3 2QG.

The Survey was undertaken by Stuart Metcalfe MIOA who has been practicing in Building Services Acoustics and Noise Control Engineering for in excess of 30 years, is a Member of the Institute of Acoustics (MIOA) and is a Director at Conabeare Acoustics Ltd.

2 Acoustic Criteria

BS4142:2014 Methods for rating and assessing industrial and commercial sound.

BS4142:2014 gives a method for rating sound from industrial and commercial sources affecting people inside or outside dwellings or premises used for residential purposes.

An initial estimate of the significance of the sound from the industrial/commercial nature can be assessed by subtracting the measured background noise level from the rating level (this is the specific sound level of the source with any corrections or penalties for distinctive acoustic characteristics).

Typically, the greater the difference, the greater the magnitude of the impact.

The site is located within the London Borough of Camden demise which has adopted the National Planning Policy Guidelines and as such References and evaluations are to be made to the National Planning Policy Framework 2012 (NPPF) and the Noise Policy Statement for England 2010 (NPSE).

There are several key phrases within the NPSE aims and these are discussed below. “Significant adverse” and “adverse”

NOEL – No Observed Effect Level - This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.

LOAEL – Lowest Observed Adverse Effect Level - This is the level above which adverse effects on health and quality of life can be detected. Extending these concepts for the purpose of this NPSE leads to the concept of a significant observed adverse effect level.

SOAEL – Significant Observed Adverse Effect Level - This is the level above which significant adverse effects on health and quality of life occur.

This Camden requirement for noise exposure are detailed in the Local Plan Appendix 3: Noise thresholds which is reproduced thus;

Industrial and Commercial Noise Sources

A relevant standard or guidance document should be referenced when determining values for LOAEL and SOAEL for non-anonymous noise. Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and 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).

Table C: *Noise levels applicable to proposed industrial and commercial developments (including plant and machinery)*

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

**10dB should be increased to 15dB if the noise contains audible tonal elements. (day and night). However, if it can be demonstrated that there is no significant difference in the character of the residual background noise and the specific noise from the proposed development then this reduction may not be required. In addition, a frequency analysis (to include, the use of Noise Rating (NR) curves or other criteria curves) for the assessment of tonal or low frequency noise may be required.*

***levels given are for dwellings, however, levels are use specific and different levels will apply dependent on the use of the premises.*

The periods in Table C correspond to 0700 hours to 2300 hours for the day and 2300 hours to 0700 hours for the night. The Council will take into account the likely times of occupation for

types of development and will be amended according to the times of operation of the establishment under consideration.
There are certain smaller pieces of equipment on commercial premises, such as extract ventilation, air conditioning units and condensers, where achievement of the rating levels (ordinarily determined by a BS:4142 assessment) may not afford the necessary protection. In these cases, the Council will generally also require a NR curve specification of NR35 or below, dependant on the room (based upon measured or predicted Leq,5mins noise levels in octave bands) 1 metre from the façade of affected premises, where the noise sensitive premise is located in a quiet background area.

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre, Station Road, Theale, Berkshire. RG7 4AA
Telephone 0118 930 3650 Facsimile 0118 930 3912
sales@conabeare.co.uk

3 Plant Location and Measurement Position

The site is located on Pond Street in the Hampstead District in North West London.

The area consists of a mixture of residential and commercial premises with the sound sensitive façade in question being adjudged to be the residential premises in Pond Street.

The nearest sound sensitive façades is at a distance of approximately 70 metres from the proposed plant. The sound sensitive facade has practically direct line of site to the plant with some screening from the external staircase.

There is also a current development for the Hospital being constructed and it is prudent to also consider this. The new development is purely commercial/healthcare in nature and is proposed to be used during day time hours only.

Sound Sensitive Facade **Measuring Location** **Proposed Plant Location**

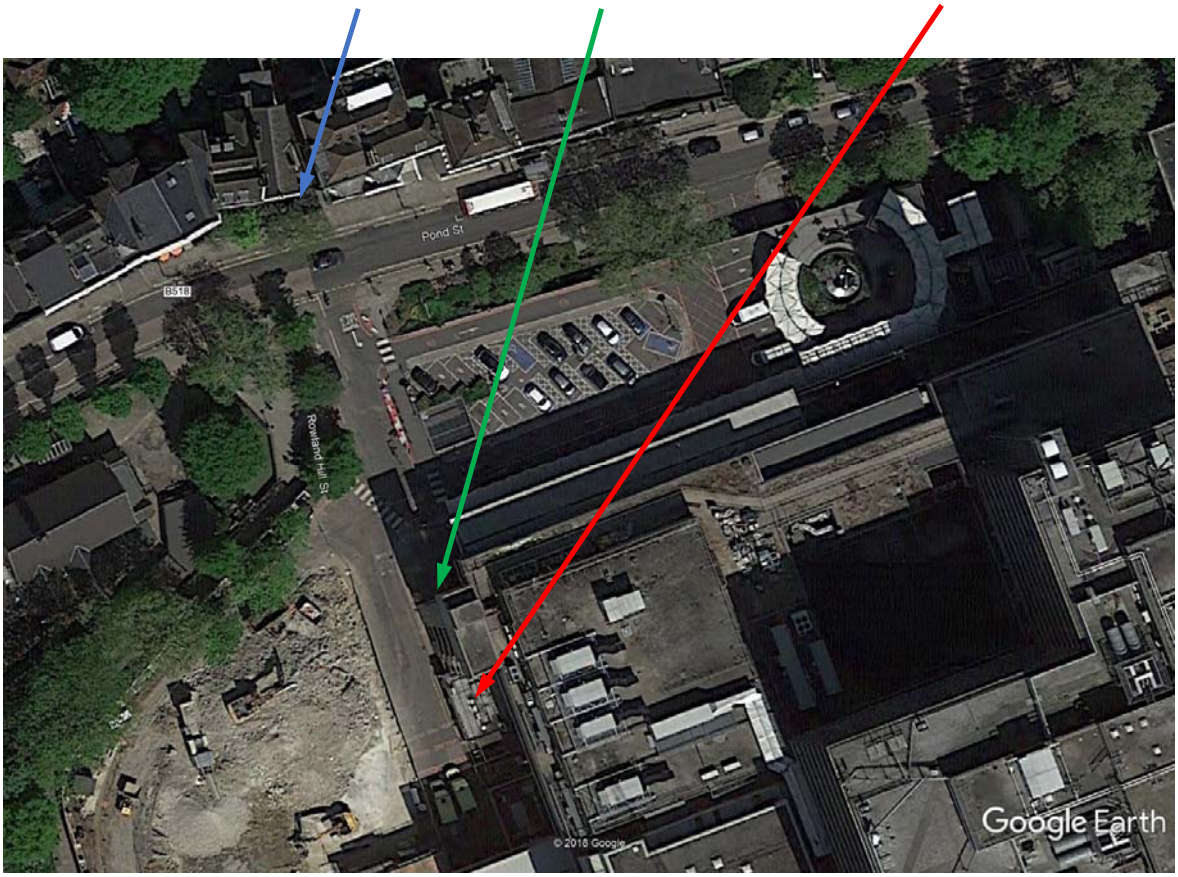


Photo 1 – Measuring Location

Photo 2 – Proposed Plant Location

4 Existing Noise Climate

The area is generally a mixture of commercial and residential premises with transportation noise from the area being adjudged to be the dominant background noise source during the survey period.

The survey location was chosen as it was close to the proposed plant location with direct views to the sound sensitive facades but away from existing plant.

5 Noise Survey

5.1 Measurements

The Survey commenced at approximately 09:50 hours on Thursday 20th December 2018 until approximately 10:00 hours on Friday 21st December 2018.

The Analyser was programmed to record 15 minute sampling periods over the survey duration.

The microphone was located on a balustrade at approximately 1.8 metres above a reflecting plane.

The measurements and their interpretation are in accordance with BS 7445: Parts 1 and 2. All readings are Sound Pressure Levels (Lp) in dB (re 20µPa).

5.2 Weather during Survey Period

The weather was cold and dry. The weather did not, in our opinion, adversely influence the readings obtained.

5.3 Instrumentation

The instrumentation used was a Type 1 Larson Davis LxT Sound Expert Sound Level Analyser confirming to IEC 651-1979 Type 1, EN60651 Type 1 and IEC 804-1985 Type 1, EN60804 Type 1.

- **Larson Davis LxT Sound Level Analyser, Serial Number 0005588.**
- **Larson Davis PRMLxT1L Preamplifier, Serial Number 055664.**

The Sound Analyser and Preamplifier are new items of equipment and were factory calibrated on 20th April 2018, Certificate Numbers 2018004098 and 2018004083 respectively.

The additional following equipment was also used

- **CEL type 284/2 Calibrator, Serial Number 4/05022369 calibrated on 21st February 2017, Certificate Number 15179.**
- **Extension Cable**

Field calibration checks were made using the Calibrator and no significant drift was noted against the Calibration level of 114.0dB ± 0.2dB at 1000Hz ± 0.2%.

5.4 Survey Results

The following is a summary of the Background (L_{A90}) levels recorded in Daytime, Evening and Night-time Periods

$L_{A90,15min}$ 59.7dB(A) between 07:00 hours to 19:00 hours.

$L_{A90,15min}$ 59.4dB(A) between 19:00 hours to 23:00 hours.

$L_{A90,15min}$ 59.0dB(A) between 23:00 hours to 07:00 hours.

6 Assessment Methodology: BS4142:2014

A revision of British Standard BS 4142 was published at the end of October 2014 and replaces the previous 1997 edition. The main aim of the standard is to provide an assessment and rating method that is proportionate, sufficiently flexible and suitable for use by practitioners to inform professional judgement. The foreword to the standard clearly states that:

"The execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced."

It does this by providing a method for the determination of:

- rating levels for sources of an industrial and/or commercial nature; and
- ambient, background and residual sound levels.

An assessment framework is provided to allow the practitioner to use the rating, ambient, background and residual sound levels determined using the standard for the purposes of:

1) investigating complaints;

2) assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature; and

3) assessing sound at proposed new dwellings or premises used for residential purposes.

The scope of the standard has now been widened to rating and assessing:

a) sound from industrial and manufacturing processes;
b) sound from fixed installations which comprise mechanical and electrical plant and equipment;
c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises; and
d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site."

It can also be seen from above that the standard explicitly states that it can be used to investigate complaints and has been significantly widened to cover not only new, modified or additional sources of sound, but also the assessment of sound affecting new dwellings or premises to be used for residential purposes.

Like the 1997 edition, the standard provides a method for correcting the specific sound levels so as to account for acoustic features that are present at the assessment location. The approach in the 1997 edition was purely subjective and allowed for a +5 dB correction irrespective of how prominent the feature was or whether there was one feature only or a combination of tones, impulses or other features irregular enough to attract attention. The 2014 edition provides for scaled corrections up to +6 dB for tones and up to +9 dB for impulses, depending upon the prominence of the tones or impulses, as well as +3 dB corrections for:

- other sound characteristics that are neither tonal nor impulsive; and/or
- intermittent features when the sound has identifiable on/off conditions.

The corrections for tones and impulses can be assessed using subjective or reference methods. There is also an objective method for tones, which is based upon the prominence of sound pressure levels in the one-third-octave-band containing a tone in comparison to the sound pressure levels in the adjacent one-third-octave-bands.

The objective method however, does not allow for different corrections to be applied for tones differing in prominence as it only allows for a single correction of +6 dB for clearly prominent tones.

The 1997 edition assessed the likelihood of complaints using the difference between the rating level and the background sound level. A difference of around +10 dB or more indicated complaints are likely, a difference of around +5 dB was of marginal significance and a difference of more than 10 dB below the background was considered to provide a positive indication that complaints were unlikely.

The 2014 edition no longer assesses the likelihood of complaints. Instead, it can be used to assess adverse impacts.

This change was introduced because the likelihood of complaints is not a particularly appropriate benchmark, especially when it is used in a planning context, and it also aligns the standard more closely with the type of language and benchmarks that are suitable for the assessment of sound at the planning stage for new proposed development.

It continues to use the difference between the rating level and the background sound level, though it also introduces the requirement to consider the context and states that:

a) Typically, the greater this difference, the greater the magnitude of the impact.

b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.

d) The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context."

The context includes consideration of pertinent factors, such as:

- the absolute level of sound;
- the character and level of the residual sound compared to the character and level of the specific sound;
- the sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions.

7 Noise Assessment

The objective of any specification limiting new noises should therefore be to ensure that sound emission from the new building services plant should not materially add to the existing sound climate.

The proposed plant being assessed is as detailed below;

- 2 number – Parker Hiross ICE310 Air Cooled Chillers (1 x run and 1 x standby)
- 3 number – M & Y AD41250 Air Handling Unit – AHU01, 02, and 03
- 8 number – Mitsubishi PUZ ZM100YKA Condensing Units

It is probable that these items have the potential to run on a 24 hour basis and as such we would recommend setting a target level at the nearest sound sensitive façade as below;

$L_{Aeq,15min}$ 49dB(A) – 24 hours.

With regard to the current development, as this is daytime operation and non-residential in nature, we would recommend setting a target level at the façade of 55dB $L_{Aeq,15min}$ (07:00 to 19:00) as this will then provide a level within the building of 40dBA based upon a loss of 15dB through the façade itself.

It is assumed that a 15dB reduction will be achieved through an even partially open window.

Parker Hiross Chiller

Specific Noise Source

The Specific Noise Source is 97dBA Lw this has been calculated using parallelepiped noise propagation from a manufacturers noise level of 65dBA at 10m.

Additional Sources

There are 2 Chillers however they are run and standby so no allowance has been made for multiple sources.

Acoustic Feature Correction

We have allowed for a 3dB Acoustic Correction Feature for the sound sensitive façade.

This item of plant is considered to be tonal but not intermittent in nature so a correction of 5dB has been made.

We have made an allowance of 3dB for reflected noise due to the location of the units. It is proposed that an acoustic absorptive screen will be utilised to reduce the reflected noise.

Distance Attenuation

The nearest sound sensitive façade is at a distance of approximately 70 metres from the proposed plant. The distance loss will therefore be 48dB based upon parallelepiped noise propagation.

Barrier Attenuation

There are line of sight barriers between the plant and the sound sensitive façade and as such a reduction of 5dB has been allowed.

BS4142 Assessment

BS4142 Assessment – 24 Hours	**dBA**
Specific Noise Level	97
Additional Sources	0
Acoustic Feature Correction	11
Distance Attenuation	-48
Barrier Attenuation	-5
Rating Level	55
Background (L_{A90}) Level	59
Rating Above Background Level	-4

This item of plant therefore is therefore 4dBA **below** the measured Background Level at the nearest noise sensitive facade.

The assessment would indicate that the plant will have an AMBER rating of *LOAEL – Lowest Observed Adverse Effect Level* as it is between 9dB below and 5dB above the measured background level.

CONABEARE ACOUSTICS

M & Y Air Handling Units

Specific Noise Source

The Specific Noise Source is 69dBA Lw which is calculated from the AHU Fan Lw levels including allowances for attenuation and mounting conditions of the fans.

Additional Sources

There are 3 AHU's so a correction of 5dB has been made for multiple sources.

Acoustic Feature Correction

We have allowed for a 3dB Acoustic Correction Feature for the sound sensitive façade.

This item of plant is not considered to be tonal or intermittent in nature so no allowance has been made.

We have made an allowance of 3dB for reflected noise due to the location of the units.

Distance Attenuation

The nearest sound sensitive façade is at a distance of approximately 70 metres from the proposed plant. The distance loss will therefore be 48dB based upon parallelepiped noise propagation.

Barrier Attenuation

There are line of sight barriers between the plant and the sound sensitive façade and as such a reduction of 5dB has been allowed.

BS4142 Assessment

BS4142 Assessment – 24 Hours	dBA
Specific Noise Level	69
Additional Sources	5
Acoustic Feature Correction	6
Distance Attenuation	-48
Barrier Attenuation	-5
Rating Level	27
Background (L_{A90}) Level	59
Rating Above Background Level	-32

This item of plant therefore is therefore 32dBA **below** the measured Background Level at the nearest noise sensitive facade.

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre, Station Road, Theale, Berkshire. RG7 4AA
Telephone 0118 930 3650 Facsimile 0118 930 3912
sales@conabeare.co.uk

The assessment would indicate that the plant will have a GREEN rating of *NOEL – No Observed Effect Level* as it is more than 10dBA below the measured background level.

Mitsubishi Condensing Units

Specific Noise Source

The Specific Noise Source is 51dBA Lp at 1 metre which is the manufacturers published noise level for these units.

Additional Sources

There are 8 condensing units so a correction of 9dB has been made for multiple sources.

Acoustic Feature Correction

We have allowed for a 3dB Acoustic Correction Feature for the sound sensitive façade.

This item of plant is considered to be tonal or intermittent in nature so a correction of 5dB has been made.

We have made an allowance of 6dB for reflected noise due to the location of the units.

Distance Attenuation

The nearest sound sensitive façade is at a distance of approximately 73 metres from the proposed plant. The additional distance loss will therefore be 38dB based upon parallelepiped noise propagation.

Barrier Attenuation

There are line of sight barriers between the plant and the sound sensitive façade and as such a reduction of 5dB has been allowed.

BS4142 Assessment

BS4142 Assessment – 24 Hours	dBA
Specific Noise Level	51
Additional Sources	9
Acoustic Feature Correction	14
Distance Attenuation	-38
Barrier Attenuation	-5
Rating Level	31
Background (L_{A90}) Level	59
Rating Above Background Level	-28

This item of plant therefore is therefore 28dBA **below** the measured Background Level at the nearest noise sensitive facade.

The assessment would indicate that the plant will have a GREEN rating of *NOEL – No Observed Effect Level* as it is more than 10dBA below the measured background level.

Combined Noise Level Assessment

As the items of plant detailed above are all running at the same time then the levels of same need to be combined.

The combined noise level for all plant is 55dBA which is dominated by the Parker Hiross Chillers.

These will be 6dBA above the target noise level and as such the combined plant will be categorized as having an AMBER rating of *LOAEL – Lowest Observed Adverse Effect Level* as it is between 9dB below and 5dB above the measured background level.

8 Recommendations

It is recommended that the chillers therefore have mitigating measures fitted to reduce the noise levels by at least 6dB.

To enable the noise levels to the Residential Sound Sensitive Façade to be met it will be necessary to fit an acoustic panel screen between the chillers and the noise sensitive facades. The acoustic panels should have the following Sound Reduction Index and should extend to a height of at least 500mm above the height of the chillers.

The acoustic panels will need to have the following minimum acoustic performance.

Sound Reduction (dB) at Octave Band Centre Frequencies (Hz)

63	125	250	500	1k	2k	4k	8k
17	16	21	30	38	42	44	38

Absorption Coefficient at Octave Band Centre Frequencies (Hz)

63	125	250	500	1k	2k	4k	8k
0.28	0.35	0.53	0.94	0.95	0.90	0.88	0.82

It is envisaged that the acoustic panels will be 50mm thick with a solid external face and an absorptive internal face.

This acoustic screen would provide the following reduction due to screening which will replace the line of sight screening in our calculations.

Screening Reduction (dB) at Octave Band Centre Frequencies (Hz)

63	125	250	500	1k	2k	4k	8k
5	6	7	9	11	13	16	18

Furthermore, it is recommended that an acoustic discharge be installed to the top of the chiller units to reduce the likelihood of recirculation of hot gasses. This discharge should be acoustically lined and approximately 600mm tall.

The discharge should be mounted independently to the chillers and will require the following acoustic performance.

Insertion Loss (dB) at Octave Band Centre Frequencies (Hz)

63	125	250	500	1k	2k	4k	8k
2	3	4	6	6	6	6	6

The above detailed mitigating measures will also assist in reducing the noise levels to the adjacent development.

9 Conclusion

A background Noise Survey was carried during a typical day and night time period at a location representative of the nearest sound sensitive receivers.

An assessment has been carried out and mitigating measures proposed.

The assessment would indicate that the plant with the proposed mitigating measures will have a GREEN rating of *NOEL – No Observed Effect Level* as it is more than 10dBA below the measured background level.

In our opinion, the scheme should be acceptable to the Local Authority if these mitigating measures are incorporated into the works.

CS8160 - The Royal Free Hospital, Pond Street, London NW3 2QG

- Period result profile -

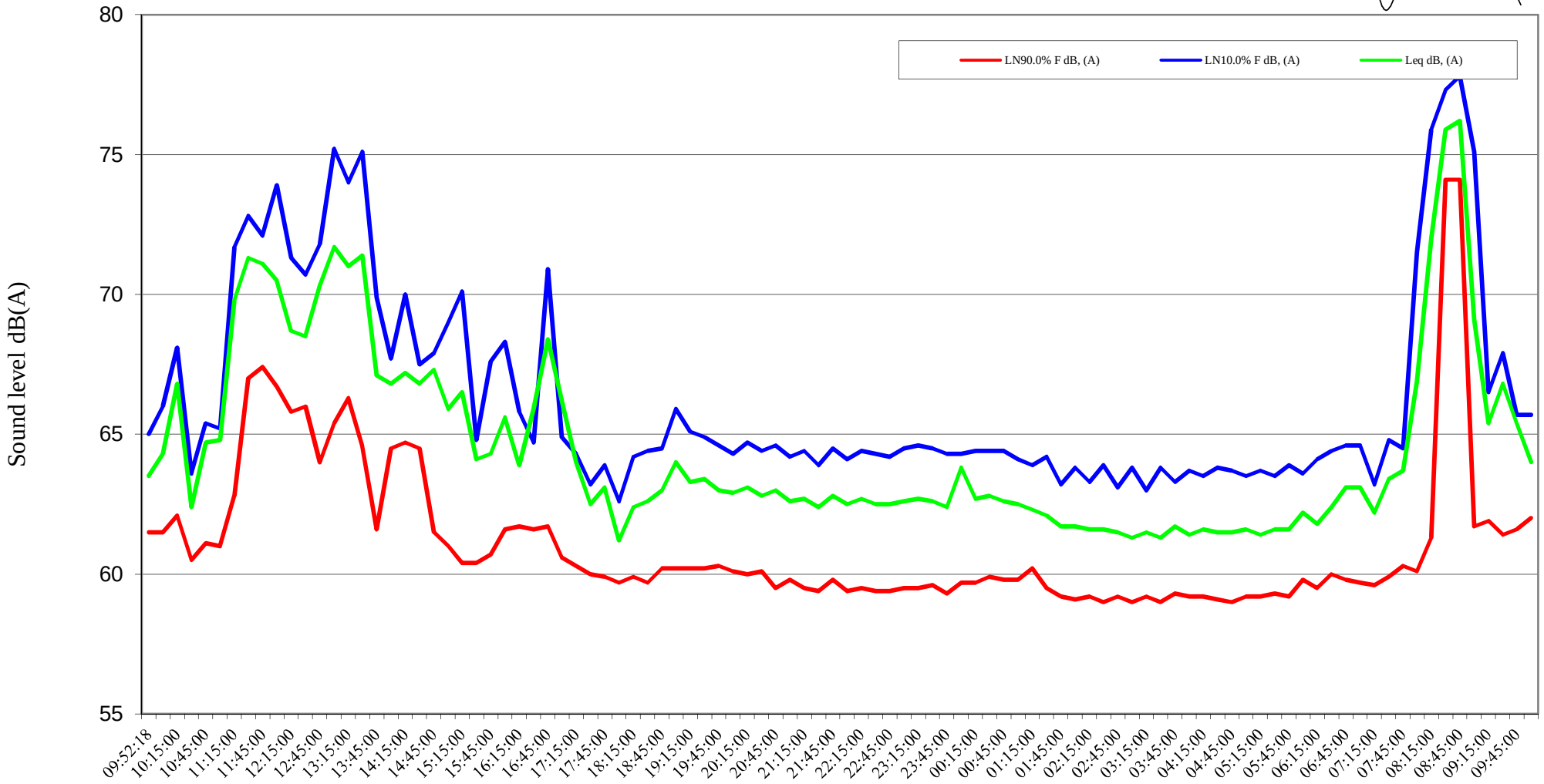
Overload occurred	No
Low battery occurred	No
Pause was used	No
Frequency weighting	A
Band	Broadband
Period time	15 min
Periods too short for LNs	No
First period listed	1 : 98
Measurement Description	
Start	20/12/2018 09:52
Stop	21/12/2018 10:04
Duration	1 Day 00:12:08.5
Run Time	1 Day 00:12:08.5
Pause	00:00.0
Pre Calibration	20/12/2018 09:48

Period number	Date	Time	LN90.0% F	LN10.0% F	Leq
			dB, (A)	dB, (A)	dB, (A)
1	20/12/2018	09:52:18	61.5	65.0	63.5
2	20/12/2018	10:00:00	61.5	66.0	64.3
3	20/12/2018	10:15:00	62.1	68.1	66.8
4	20/12/2018	10:30:00	60.5	63.6	62.4
5	20/12/2018	10:45:00	61.1	65.4	64.7
6	20/12/2018	11:00:00	61	65.2	64.8
7	20/12/2018	11:15:00	62.8	71.7	69.8
8	20/12/2018	11:30:00	67	72.8	71.3
9	20/12/2018	11:45:00	67.4	72.1	71.1
10	20/12/2018	12:00:00	66.7	73.9	70.5
11	20/12/2018	12:15:00	65.8	71.3	68.7
12	20/12/2018	12:30:00	66	70.7	68.5
13	20/12/2018	12:45:00	64	71.8	70.3
14	20/12/2018	13:00:00	65.4	75.2	71.7
15	20/12/2018	13:15:00	66.3	74	71
16	20/12/2018	13:30:00	64.6	75.1	71.4
17	20/12/2018	13:45:00	61.6	69.9	67.1
18	20/12/2018	14:00:00	64.5	67.7	66.8
19	20/12/2018	14:15:00	64.7	70	67.2
20	20/12/2018	14:30:00	64.5	67.5	66.8
21	20/12/2018	14:45:00	61.5	67.9	67.3
22	20/12/2018	15:00:00	61	69	65.9
23	20/12/2018	15:15:00	60.4	70.1	66.5
24	20/12/2018	15:30:00	60.4	64.8	64.1
25	20/12/2018	15:45:00	60.7	67.6	64.3
26	20/12/2018	16:00:00	61.6	68.3	65.6
27	20/12/2018	16:15:00	61.7	65.8	63.9
28	20/12/2018	16:30:00	61.6	64.7	65.9
29	20/12/2018	16:45:00	61.7	70.9	68.4
30	20/12/2018	17:00:00	60.6	64.9	66.2
31	20/12/2018	17:15:00	60.3	64.3	64
32	20/12/2018	17:30:00	60	63.2	62.5
33	20/12/2018	17:45:00	59.9	63.9	63.1
34	20/12/2018	18:00:00	59.7	62.6	61.2
35	20/12/2018	18:15:00	59.9	64.2	62.4
36	20/12/2018	18:30:00	59.7	64.4	62.6
37	20/12/2018	18:45:00	60.2	64.5	63
38	20/12/2018	19:00:00	60.2	65.9	64

Period number	Date	Time	LN90.0% F	LN10.0% F	Leq
			dB, (A)	dB, (A)	dB, (A)
39	20/12/2018	19:15:00	60.2	65.1	63.3
40	20/12/2018	19:30:00	60.2	64.9	63.4
41	20/12/2018	19:45:00	60.3	64.6	63
42	20/12/2018	20:00:00	60.1	64.3	62.9
43	20/12/2018	20:15:00	60	64.7	63.1
44	20/12/2018	20:30:00	60.1	64.4	62.8
45	20/12/2018	20:45:00	59.5	64.6	63
46	20/12/2018	21:00:00	59.8	64.2	62.6
47	20/12/2018	21:15:00	59.5	64.4	62.7
48	20/12/2018	21:30:00	59.4	63.9	62.4
49	20/12/2018	21:45:00	59.8	64.5	62.8
50	20/12/2018	22:00:00	59.4	64.1	62.5
51	20/12/2018	22:15:00	59.5	64.4	62.7
52	20/12/2018	22:30:00	59.4	64.3	62.5
53	20/12/2018	22:45:00	59.4	64.2	62.5
54	20/12/2018	23:00:00	59.5	64.5	62.6
55	20/12/2018	23:15:00	59.5	64.6	62.7
56	20/12/2018	23:30:00	59.6	64.5	62.6
57	20/12/2018	23:45:00	59.3	64.3	62.4
58	21/12/2018	00:00:00	59.7	64.3	63.8
59	21/12/2018	00:15:00	59.7	64.4	62.7
60	21/12/2018	00:30:00	59.9	64.4	62.8
61	21/12/2018	00:45:00	59.8	64.4	62.6
62	21/12/2018	01:00:00	59.8	64.1	62.5
63	21/12/2018	01:15:00	60.2	63.9	62.3
64	21/12/2018	01:30:00	59.5	64.2	62.1
65	21/12/2018	01:45:00	59.2	63.2	61.7
66	21/12/2018	02:00:00	59.1	63.8	61.7
67	21/12/2018	02:15:00	59.2	63.3	61.6
68	21/12/2018	02:30:00	59	63.9	61.6
69	21/12/2018	02:45:00	59.2	63.1	61.5
70	21/12/2018	03:00:00	59	63.8	61.3
71	21/12/2018	03:15:00	59.2	63	61.5
72	21/12/2018	03:30:00	59	63.8	61.3
73	21/12/2018	03:45:00	59.3	63.3	61.7
74	21/12/2018	04:00:00	59.2	63.7	61.4
75	21/12/2018	04:15:00	59.2	63.5	61.6
76	21/12/2018	04:30:00	59.1	63.8	61.5
77	21/12/2018	04:45:00	59	63.7	61.5
78	21/12/2018	05:00:00	59.2	63.5	61.6
79	21/12/2018	05:15:00	59.2	63.7	61.4
80	21/12/2018	05:30:00	59.3	63.5	61.6
81	21/12/2018	05:45:00	59.2	63.9	61.6
82	21/12/2018	06:00:00	59.8	63.6	62.2
83	21/12/2018	06:15:00	59.5	64.1	61.8
84	21/12/2018	06:30:00	60	64.4	62.4
85	21/12/2018	06:45:00	59.8	64.6	63.1
86	21/12/2018	07:00:00	59.7	64.6	63.1
87	21/12/2018	07:15:00	59.6	63.2	62.2
88	21/12/2018	07:30:00	59.9	64.8	63.4
89	21/12/2018	07:45:00	60.3	64.5	63.7
90	21/12/2018	08:00:00	60.1	71.5	66.9
91	21/12/2018	08:15:00	61.3	75.9	72
92	21/12/2018	08:30:00	74.1	77.3	75.9
93	21/12/2018	08:45:00	74.1	77.8	76.2
94	21/12/2018	09:00:00	61.7	75.1	69.1
95	21/12/2018	09:15:00	61.9	66.5	65.4
96	21/12/2018	09:30:00	61.4	67.9	66.8
97	21/12/2018	09:45:00	61.6	65.7	65.4

Period number	Date	Time	LN90.0% F	LN10.0% F	Leq
			dB, (A)	dB, (A)	dB, (A)
98	21/12/2018	10:00:00	62	65.7	64

CS8160 - Royal Free Hospital, Pond Street, London NW3 2QG



CONABEARE ACOUSTICS

Glossary of Terms

L_{A90}	The sound pressure level in dB(A) which is exceeded for 90% of the time and is taken to be the effective lowest background sound level for the period by such methods of sound rating as that recommended in BS4142:2014. It will also be used as a basis for selecting limiting sound levels from new plant by Local Planning Authorities when setting Planning Consent Conditions.
L_{eq}	The "equivalent continuous sound level" for the measuring period, defined as the level in dBA which, if held constant over the measuring period, would produce the same amount of sound energy as does the actual varying ambient sound level. It is a measure of the amount of sound energy affecting the site from sources other than new plant or operations.
L_{A10}	The sound level exceeded for 10% of the time over the sample period. Originally used as a measure of subjective reaction to traffic noise in particular, it can also be taken as an indication of the practical maximum sound level that the building envelope will have to protect against.
dBA	Describes measured on a sound level meter incorporating a frequency weighting (A weighting) which differentiates between sounds of different frequency (pitch) in a similar way to the human ear. Measurements in dBA broadly agree with people's assessment of loudness. A change of 3dBA is the minimum perceptible under normal conditions, and a change of 10dBA corresponds roughly to halving or doubling the loudness of a sound.

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre, Station Road, Theale, Berkshire. RG7 4AA
Telephone 0118 930 3650 Facsimile 0118 930 3912
sales@conabeare.co.uk

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre
Station Road, Theale
Berkshire RG7 4AA
Telephone 0118 930 3650
Facsimile 0118 930 3912
sales@conabeare.co.uk

CONABEARE ACOUSTICS

Project: CS8160 - Royal Free Hospital - Proposed MRI Unit
Client : Royal Free London NHS Foundation Trust
Revision: Revision A
Date : 25th April 2019

Calculation 02

Item **Proposed Plant - Target Level - 49dBA at 1 metre from Nearest Sound Sensitive Façade - with Mitigating Measures**

Air Handling Units - M&Y Ventilation Equipment Limited

	AHU - Fresh Air Intake - Atmospheric Noise			63	125	250	500	1k	2k	4k	8k	dBA
	Unit Lw - Manufacturers Data			**78**	**74**	**76**	**72**	**67**	**67**	**63**	**58**	**74**
	Attenuator - M&Y Ventilation Equipment Limited data			-3	-7	-14	-28	-37	-37	-29	-24	
	Estimated Lw at Terminal - Fresh Air Intake Only			**75**	**67**	**62**	**44**	**30**	**30**	**34**	**34**	**56**
	AHU - Exhaust - Atmospheric Noise			**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Unit Lw - Manufacturers Data			**74**	**73**	**81**	**84**	**86**	**84**	**79**	**76**	**90**
	Attenuator - M&Y Ventilation Equipment Limited data			-3	-7	-14	-28	-37	-37	-29	-24	
	Estimated Lw at Terminal - Exhaust Only			**71**	**66**	**67**	**56**	**49**	**47**	**50**	**52**	**61**
	Addition for mounting position of fans			**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	
	Cumulative Noise Level - AHU			**82**	**76**	**74**	**62**	**55**	**53**	**56**	**58**	**69**
	Additional Sources - 3 units			5	5	5	5	5	5	5	5	
	Distance to Listener	70	m	-48	-48	-48	-48	-48	-48	-48	-48	
	Additional Surfaces			3	3	3	3	3	3	3	3	
	Line of sight screening			-5	-5	-5	-5	-5	-5	-5	-5	
	Façade Effect			3	3	3	3	3	3	3	3	
1	**Estimated Lp at Listener - Combined - All AHU's**			**40**	**34**	**32**	**20**	**13**	**11**	**14**	**16**	**27**

Chiller Units - Parker Hiross Limited

	Chiller - ICE310			63	125	250	500	1k	2k	4k	8k	dBA
	Unit Lw - Manufacturers Data			**87**	**91**	**94**	**96**	**94**	**89**	**82**	**73**	**98**
	Distance to Listener	70	m	-48	-48	-48	-48	-48	-48	-48	-48	
	Correction for tonality			5	5	5	5	5	5	5	5	
	Additional Surfaces			3	3	3	3	3	3	3	3	
	Acoustic Screening - screen 500mm taller than chiller.			-5	-6	-7	-9	-11	-13	-16	-18	
	Acoustic Discharge to Chiller Fans			-2	-3	-4	-6	-6	-6	-6	-6	
	Façade Effect			3	3	3	3	3	3	3	3	
2	**Estimated Lp at Listener - Chiller Only**			**43**	**45**	**46**	**44**	**40**	**33**	**23**	**12**	**45**

Condensing Units - Mitsubishi

	Condensing Units - PUZ ZM100YKA			63	125	250	500	1k	2k	4k	8k	dBA
	Unit Lp at 1 metre - Manufacturers Data			**54**	**54**	**53**	**49**	**46**	**41**	**36**	**29**	**51**
	Additional Sources (7)			**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	
	Additional Distance to Listener	73	m	-38	-38	-38	-38	-38	-38	-38	-38	
	Correction for intermittent noise			5	5	5	5	5	5	5	5	
	Additional Surfaces			6	6	6	6	6	6	6	6	
	Acoustic Screening - screen 500mm taller than chiller.			-5	-6	-7	-9	-11	-13	-16	-18	
	Façade Effect			3	3	3	3	3	3	3	3	
3	**Estimated Lp at Listener - Condensing Units Only**			**34**	**33**	**31**	**25**	**20**	**13**	**5**	**0**	**27**
	Cumulative Noise Level			**45**	**45**	**46**	**44**	**40**	**33**	**24**	**18**	**45**

Conabeare Acoustics Limited
11 Chiltern Enterprise Centre
Station Road, Theale
Berkshire RG7 4AA
Telephone 0118 930 3650
Facsimile 0118 930 3912
sales@conabeare.co.uk

CONABEARE ACOUSTICS

Project: CS8160 - Royal Free Hospital - Proposed MRI Unit
Client : Royal Free London NHS Foundation Trust
Revision: Revision A
Date : 25th April 2019

Calculation 03

Item **Proposed Plant - Target Level - 55dBA at 1 metre from New Development**

Air Handling Units - M&Y Ventilation Equipment Limited

	AHU - Fresh Air Intake - Atmospheric Noise			**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Unit Lw - Manufacturers Data			**78**	**74**	**76**	**72**	**67**	**67**	**63**	**58**	**74**
	Attenuator - M&Y Ventilation Equipment Limited data			-3	-7	-14	-28	-37	-37	-29	-24	
	Estimated Lw at Terminal - Fresh Air Intake Only			**75**	**67**	**62**	**44**	**30**	**30**	**34**	**34**	**56**

	AHU - Exhaust - Atmospheric Noise			**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Unit Lw - Manufacturers Data			**74**	**73**	**81**	**84**	**86**	**84**	**79**	**76**	**90**
	Attenuator - M&Y Ventilation Equipment Limited data			-3	-7	-14	-28	-37	-37	-29	-24	
	Estimated Lw at Terminal - Exhaust Only			**71**	**66**	**67**	**56**	**49**	**47**	**50**	**52**	**61**
	Addition for mounting position of fans			**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	
	Cumulative Noise Level - AHU			**82**	**76**	**74**	**62**	**55**	**53**	**56**	**58**	**69**
	Additional Sources - 3 units			5	5	5	5	5	5	5	5	
	Distance to Listener	11	m	-32	-32	-32	-32	-32	-32	-32	-32	
	Additional Surfaces			3	3	3	3	3	3	3	3	
	Partial Line of Sight Screening			-5	-5	-5	-5	-5	-5	-5	-5	
	Façade Effect			3	3	3	3	3	3	3	3	
1	**Estimated Lp at Listener - Combined - All AHU's**			**56**	**50**	**48**	**36**	**29**	**27**	**30**	**32**	**43**

Chiller Units - Parker Hiross Limited

	Chiller - ICE310			**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Unit Lw - Manufacturers Data			**87**	**91**	**94**	**96**	**94**	**89**	**82**	**73**	**98**
	Distance to Listener	16	m	-36	-36	-36	-36	-36	-36	-36	-36	
	Correction for tonality			5	5	5	5	5	5	5	5	
	Additional Surfaces			3	3	3	3	3	3	3	3	
	Acoustic Screening - screen 500mm taller than chiller.			-5	-6	-7	-9	-11	-13	-16	-18	
	Acoustic Discharge to Chiller Fans			-2	-3	-4	-6	-6	-6	-6	-6	
	Façade Effect			3	3	3	3	3	3	3	3	
2	**Estimated Lp at Listener - Chiller Only**			**55**	**57**	**58**	**56**	**52**	**45**	**35**	**24**	**57**

Condensing Units - Mitsubishi

	Condensing Units - PUZ ZM100YKA			**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**dBA**
	Unit Lp at 1 metre - Manufacturers Data			**54**	**54**	**53**	**49**	**46**	**41**	**36**	**29**	**51**
	Additional Sources (7)			**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	
	Additional Distance to Listener	16	m	-25	-25	-25	-25	-25	-25	-25	-25	
	Correction for intermittent noise			5	5	5	5	5	5	5	5	
	Additional Surfaces			6	6	6	6	6	6	6	6	
	Partial Line of Sight Screening			-5	-5	-5	-5	-5	-5	-5	-5	
	Façade Effect			3	3	3	3	3	3	3	3	
3	**Estimated Lp at Listener - Condensing Units Only**			**47**	**47**	**46**	**42**	**39**	**34**	**29**	**22**	**44**

	Cumulative Noise Level			**59**	**58**	**58**	**56**	**52**	**45**	**36**	**33**	**57**

Calibration Certificate

Certificate Number 2018004098

Customer:

PC Environmental Ltd.
Unit 11 Mill Court
The Sawmills, Durley
Southampton, S032 2EJ, United Kingdom

Model Number	LxT SE
Serial Number	0005588
Test Results	**Pass**
Initial Condition	As Manufactured
Description	Sound Expert LxT Class 1 Sound Level Meter Firmware Revision: 2.302

Procedure Number	D0001.8384		
Technician	Ron Harris		
Calibration Date	20 Apr 2018		
Calibration Due			
Temperature	23.64	°C	± 0.25 °C
Humidity	50.4	%RH	± 2.0 %RH
Static Pressure	85.99	kPa	± 0.13 kPa

Evaluation Method

Tested with:

Larson Davis PRMLxT1L. S/N 055664
PCB 377B02. S/N 304334
Larson Davis CAL200. S/N 9079
Larson Davis CAL291. S/N 0108

Data reported in dB re 20 µPa.

Compliance Standards

Compliant to Manufacturer Specifications and the following standards when combined with Calibration Certificate from procedure D0001.8378:

IEC 60651:2001 Type 1	ANSI S1.4-2014 Class 1
IEC 60804:2000 Type 1	ANSI S1.4 (R2006) Type 1
IEC 61252:2002	ANSI S1.11 (R2009) Class 1
IEC 61260:2001 Class 1	ANSI S1.25 (R2007)
IEC 61672:2013 Class 1	ANSI S1.43 (R2007) Type 1

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2008.

This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Correction data from Larson Davis LxT Manual for SoundTrack LxT & SoundExpert Lxt, I770.01 Rev J Supporting Firmware Version 2.301, 2015-04-30

For 1/4" microphones, the Larson Davis ADP024 1/4" to 1/2" adaptor is used with the calibrators and the Larson Davis ADP043 1/4" to 1/2" adaptor is used with the preamplifier.

Calibration Check Frequency: 1000 Hz; Reference Sound Pressure Level: 114 dB re 20 µPa

Periodic tests were performed in accordance with precedures from IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part3.

No Pattern approval for IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 available.

The sound level meter submitted for testing successfully completed the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3, for the environmental conditions under which the tests were performed. However, no general statement or conclusion can be made about conformance of the sound level meter to the full specifications of IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 because (a) evidence was not publicly available, from an independent testing organization responsible for pattern approvals, to demonstrate that the model of sound level meter fully conformed to the class 1 specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1 or correction data for acoustical test of frequency weighting were not provided in the Instruction Manual and (b) because the periodic tests of IEC 61672-3:2013 / ANSI/ASA S1.4-2014/Part 3 cover only a limited subset of the specifications in IEC 61672-1:2013 / ANSI/ASA S1.4-2014/Part 1.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Larson Davis CAL291 Residual Intensity Calibrator	2017-09-19	2018-09-19	001250
SRS DS360 Ultra Low Distortion Generator	2017-06-23	2018-06-23	006311
Hart Scientific 2626-S Humidity/Temperature Sensor	2017-06-11	2018-06-11	006943
Larson Davis CAL200 Acoustic Calibrator	2017-07-25	2018-07-25	007027
Larson Davis Model 831	2018-02-28	2019-02-28	007182
PCB 377A13 1/2 inch Prepolarized Pressure Microphone	2018-03-07	2019-03-07	007185

Acoustic Calibration

Measured according to IEC 61672-3:2013 10 and ANSI S1.4-2014 Part 3: 10

Measurement	Test Result [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
1000 Hz	114.00	113.80	114.20	0.14	Pass

Acoustic Signal Tests, C-weighting

Measured according to IEC 61672-3:2013 12 and ANSI S1.4-2014 Part 3: 12 using a comparison coupler with Unit Under Test (UUT) and reference SLM using slow time-weighted sound level for compliance to IEC 61672-1:2013 5.5; ANSI S1.4-2014 Part 1: 5.5

Frequency [Hz]	Test Result [dB]	Expected [dB]	Lower Limit [dB]	Upper Limit [dB]	Expanded Uncertainty [dB]	Result
125	-0.21	-0.20	-1.20	0.80	0.23	Pass
1000	0.19	0.00	-0.70	0.70	0.23	Pass
8000	-2.60	-3.00	-5.50	-1.50	0.32	Pass

-- End of measurement results--

Self-generated Noise

Measured according to IEC 61672-3:2013 11.1 and ANSI S1.4-2014 Part 3: 11.1

Measurement	Test Result [dB]
A-weighted	44.37

-- End of measurement results--

-- End of Report--

Signatory: *Ron Harris*

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.

Calibration Certificate

Certificate Number 2018004083
Customer:
PC Environmental Ltd.
Unit 11 Mill Court
The Sawmills, Durley
Southampton, S032 2EJ, United Kingdom

Model Number	PRMLxT1L	***Procedure Number***	D0001.8383		
Serial Number	055664	***Technician***	Ron Harris		
Test Results	**Pass**	***Calibration Date***	20 Apr 2018		
Initial Condition	As Manufactured	***Calibration Due***			
		Temperature	23.64	°C	± 0.01 °C
Description	Larson Davis 1/2" Preamplifier for LxT Class 1 -1 dB	***Humidity***	50.9	%RH	± 0.5 %RH
		Static Pressure	85.87	kPa	± 0.03 kPa

Evaluation Method Tested electrically using a 12.0 pF capacitor to simulate microphone capacitance. Data reported in dB re 20 µPa assuming a microphone sensitivity of 50.0 mV/Pa.

Compliance Standards Compliant to Manufacturer Specifications

Issuing lab certifies that the instrument described above meets or exceeds all specifications as stated in the referenced procedure (unless otherwise noted). It has been calibrated using measurement standards traceable to the SI through the National Institute of Standards and Technology (NIST), or other national measurement institutes, and meets the requirements of ISO/IEC 17025:2005.
Test points marked with a ‡ in the uncertainties column do not fall within this laboratory's scope of accreditation.

The quality system is registered to ISO 9001:2008.

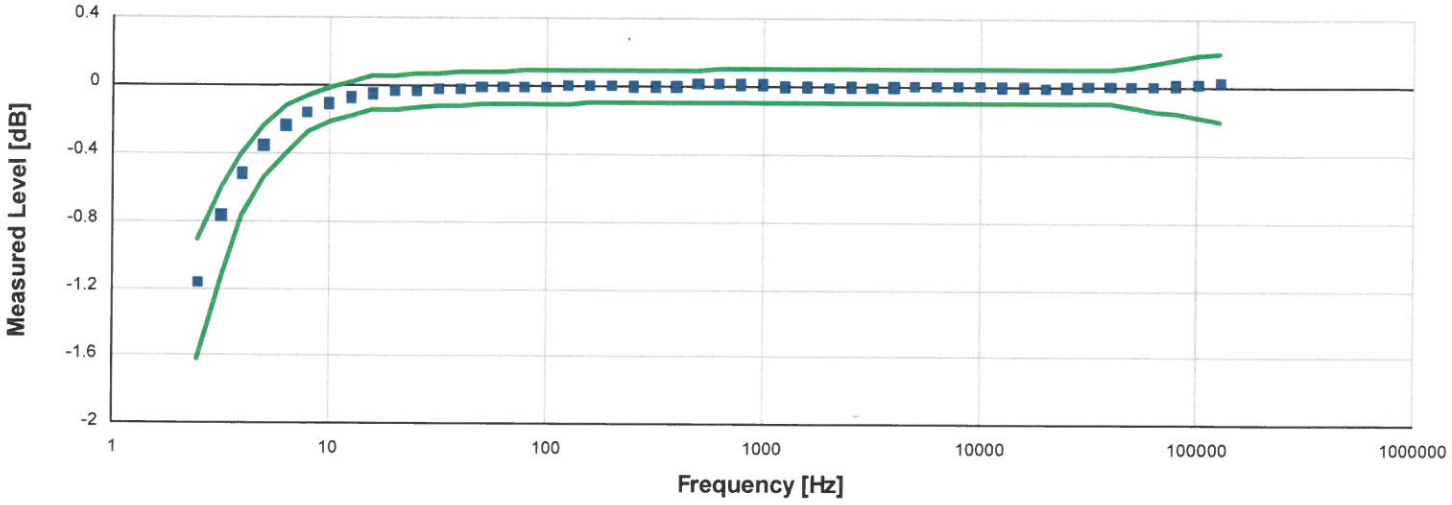
This calibration is a direct comparison of the unit under test to the listed reference standards and did not involve any sampling plans to complete. No allowance has been made for the instability of the test device due to use, time, etc. Such allowances would be made by the customer as needed.

The uncertainties were computed in accordance with the ISO Guide to the Expression of Uncertainty in Measurement (GUM). A coverage factor of approximately 2 sigma (k=2) has been applied to the standard uncertainty to express the expanded uncertainty at approximately 95% confidence level.

Standards Used

Description	Cal Date	Cal Due	Cal Standard
Larson Davis Model 2900 Real Time Analyzer	03/07/2018	03/07/2019	003003
Hart Scientific 2626-S Humidity/Temperature Sensor	06/11/2017	06/11/2018	006943
Agilent 34401A DMM	06/28/2017	06/28/2018	007165
SRS DS360 Ultra Low Distortion Generator	10/05/2017	10/05/2018	007167

Frequency Response



Frequency response electrically tested at 120.0 dB re 1 µV

Frequency [Hz]	Test Result [dB re 1 kHz]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
2.50	-1.17	-1.62	-0.91	0.07	Pass
3.20	-0.77	-1.14	-0.60	0.08	Pass
4.00	-0.52	-0.77	-0.40	0.08	Pass
5.00	-0.36	-0.54	-0.24	0.07	Pass
6.30	-0.24	-0.40	-0.12	0.07	Pass
7.90	-0.16	-0.28	-0.06	0.07	Pass
10.00	-0.11	-0.22	-0.01	0.07	Pass
12.60	-0.07	-0.18	0.02	0.07	Pass
15.80	-0.05	-0.15	0.05	0.07	Pass
20.00	-0.03	-0.14	0.06	0.07	Pass
25.10	-0.03	-0.13	0.07	0.07	Pass
31.60	-0.02	-0.12	0.07	0.07	Pass
39.80	-0.02	-0.12	0.08	0.07	Pass
50.10	-0.01	-0.11	0.08	0.07	Pass
63.10	-0.01	-0.11	0.08	0.07	Pass
79.40	-0.01	-0.11	0.09	0.07	Pass
100.00	-0.01	-0.11	0.09	0.07	Pass
125.90	0.00	-0.11	0.09	0.07	Pass
158.50	0.00	-0.10	0.09	0.07	Pass
199.50	0.00	-0.10	0.09	0.07	Pass
251.20	0.00	-0.10	0.09	0.07	Pass
316.20	0.00	-0.10	0.09	0.07	Pass
398.10	0.00	-0.10	0.09	0.07	Pass
501.20	0.01	-0.10	0.09	0.07	Pass
631.00	0.01	-0.10	0.10	0.07	Pass
794.30	0.01	-0.10	0.10	0.07	Pass
1,000.00	0.01	-0.10	0.10	0.07	Pass
1,258.90	0.00	-0.10	0.10	0.07	Pass
1,584.90	0.00	-0.10	0.10	0.07	Pass
1,995.30	-0.01	-0.10	0.10	0.07	Pass
2,511.90	0.00	-0.10	0.10	0.07	Pass
3,162.30	-0.01	-0.10	0.10	0.07	Pass

Frequency [Hz]	Test Result [dB re 1 kHz]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
3,981.10	0.00	-0.10	0.10	0.07	Pass
5,011.90	0.00	-0.10	0.10	0.07	Pass
6,309.60	0.00	-0.10	0.10	0.07	Pass
7,943.30	0.00	-0.10	0.10	0.07	Pass
10,000.00	0.00	-0.10	0.10	0.07	Pass
12,589.30	0.00	-0.10	0.10	0.07	Pass
15,848.90	0.00	-0.10	0.10	0.07	Pass
19,952.60	0.00	-0.10	0.10	0.07	Pass
25,118.90	0.00	-0.10	0.10	0.07	Pass
31,622.80	0.00	-0.10	0.10	0.07	Pass
39,810.70	0.00	-0.10	0.10	0.07	Pass
50,118.70	0.00	-0.12	0.12	0.08	Pass
63,095.70	0.01	-0.14	0.14	0.08	Pass
79,432.80	0.01	-0.16	0.16	0.08	Pass
100,000.00	0.02	-0.18	0.18	0.08	Pass
125,892.50	0.02	-0.20	0.20	0.22	Pass

Gain Measurement

Measurement	Test Result [dB]	Lower limit [dB]	Upper limit [dB]	Expanded Uncertainty [dB]	Result
Output Gain @ 1 kHz	-1.78	-2.60	-1.00	0.03	Pass

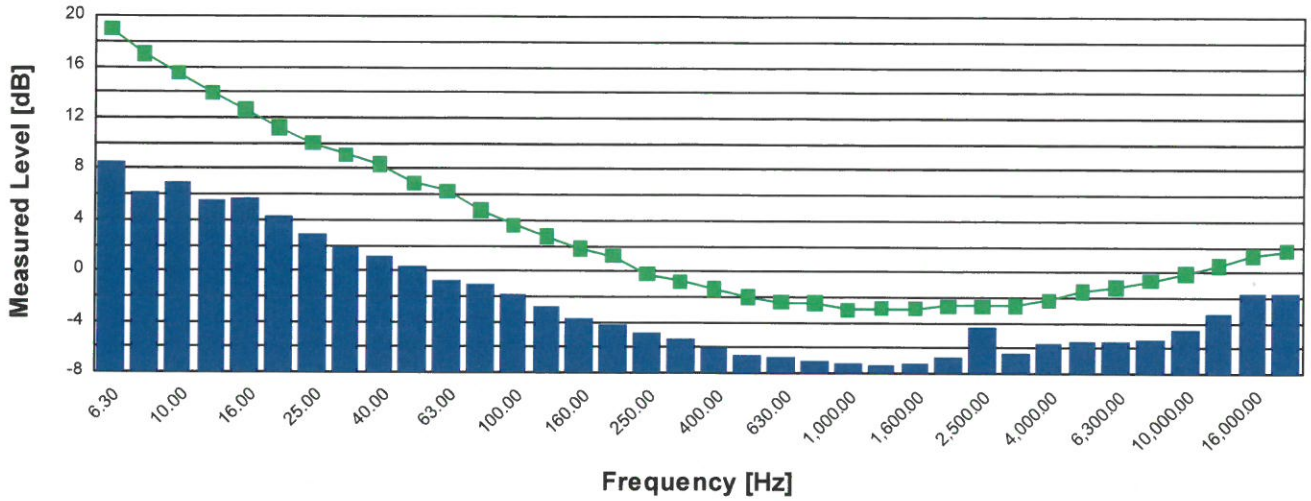
-- End of measurement results--

DC Bias Measurement

Measurement	Test Result [V]	Lower limit [V]	Upper limit [V]	Expanded Uncertainty [V]	Result
DC Voltage	3.30	2.90	3.80	0.01	Pass

-- End of measurement results--

1/3-Octave Self-Generated Noise



Frequency [Hz]	Test Result [dB re 1 µV]	Upper limit [dB re 1 µV]	Result
6.30	8.50	19.00	Pass
8.00	6.20	17.00	Pass
10.00	6.90	15.50	Pass
12.50	5.50	14.00	Pass
16.00	5.70	12.60	Pass
20.00	4.30	11.20	Pass
25.00	2.90	10.00	Pass
31.50	2.00	9.10	Pass
40.00	1.10	8.40	Pass
50.00	0.40	6.90	Pass
63.00	-0.70	6.30	Pass
80.00	-1.10	4.80	Pass
100.00	-1.90	3.60	Pass
125.00	-2.80	2.70	Pass
160.00	-3.70	1.80	Pass
200.00	-4.20	1.20	Pass
250.00	-4.80	-0.20	Pass
315.00	-5.30	-0.80	Pass
400.00	-5.90	-1.40	Pass
500.00	-6.50	-2.00	Pass
630.00	-6.70	-2.40	Pass
800.00	-7.00	-2.50	Pass
1,000.00	-7.20	-3.00	Pass
1,250.00	-7.30	-2.90	Pass
1,600.00	-7.20	-2.90	Pass
2,000.00	-6.70	-2.70	Pass
2,500.00	-4.40	-2.70	Pass
3,150.00	-6.40	-2.60	Pass
4,000.00	-5.60	-2.20	Pass
5,000.00	-5.50	-1.50	Pass
6,300.00	-5.50	-1.20	Pass
8,000.00	-5.30	-0.70	Pass
10,000.00	-4.50	-0.10	Pass
12,500.00	-3.20	0.50	Pass
16,000.00	-1.70	1.30	Pass
20,000.00	-1.70	1.70	Pass

-- End of measurement results--

Self-generated Noise

Bandwidth	Test Result [µV]	Test Result [dB re 1 µV]	Upper limit [dB re 1 µV]	Result
A-weighted (1 Hz - 20 kHz)	2.04	6.20	8.00	Pass
Broadband (1 Hz - 20 kHz)	3.98	12.00	14.00	Pass

-- End of measurement results--

Signatory: *Ron Harris*

Larson Davis, a division of PCB Piezotronics, Inc
1681 West 820 North
Provo, UT 84601, United States
716-684-0001

ACCREDITED Cert. #3622.01

LARSON DAVIS
A PCB PIEZOTRONICS DIV.