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Project:

UCL - Main Quad Pop up building

Title:

Plant Noise Impact Assessment

quietly moving forward

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Client	Fowler Martin
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Revision	Date	Author	Checked
0	31/01/17	Marek Olik	Jun Mudd

CONTENTS:

1 INTRODUCTION

1.01 Environmental Equipment Corporation Limited has been commissioned by Fowler Martin to undertake an assessment of the noise impact from three new *Mitsubishi* condenser units and four *Nuaire* air handling units to serve a teaching facility that is proposed to be constructed within the Main Quad of University College London, Gower Street, London.

1.02 The noise assessment has been conducted in accordance with the relevant standards, policies and requirements of the London Borough of Camden Council (LBCC) and includes a noise survey carried out at the site over a typical mid-week period.

1.03 The assessment includes:

- the setting of plant noise limits in accordance with the requirements of LBCC and national planning policy, standards and guidance; and
- the prediction of noise impacts from the proposed condenser in the vicinity of the plant area and at the most affected noise sensitive receptors.

1.04 This report is prepared solely for Fowler Martin. Environmental Equipment Corporation Limited accepts no responsibility for its use by any third party.

1.05 Whilst every effort has been made to ensure that this report is easy to understand, it is necessarily technical in nature. To assist the reader, an explanation of the terminology used in this report is contained in Appendix A.

2 SITE

2.01 The proposed teaching facility is a two-storey building to be located on the southern part of the UCL's Main Quad. A decorative vinyl mesh is to be installed around the perimeter of the building.

2.02 The property is bound by walkways of the Main Quad, with the following buildings beyond:

- North – Wilkins;
- East – South Cloisters;
- South – South Wing; and
- West – Chadwick.

The location of the proposed building is indicated on the site plan in Appendix B.

2.03 The proposed plant consists of 3 No. *Mitsubishi* condensers- 1 No. *PUHZ-ZRP50VKA* unit as well as 2 No. *PUMY-P200YKM* units all to be located on the ground floor at the south elevation of the proposed building.

There are also to be 6 No. *Nuaire* air handling units to be located internally. These will all be intaking air at the roof level. Two of these AHUs are to be located inside the Eastern section of the building and exhausting eastwards while the remaining four are to be located at the western side and exhausting in between the east and west sections of the proposed building.

This is as shown in the site plan in Appendix B.

2.04 The most affected noise sensitive receptors to the proposed plant items will be the office and teaching room windows on the north-western elevation of the South Wing building, indicated in the site plan in Appendix B.

2.05 All other noise sensitive receptors are at a greater distance from the proposed location of the units, or are protected by more screening by the intervening structures, and as such will be subject to lower levels of noise.

3 GUIDANCE

3.01 Guidance on noise management, control and rating pertinent to this application is provided by the planning policy for LBCC, National Planning Policy Framework (NPPF), the Noise Policy Statement for England (NPSE), and British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' (BS4142:2014). The relevant parts of these documents are presented in Appendix C.

3.02 Typically, LBCC require that noise from new mechanical services is designed to a level of at least 5 or 10 dB below the existing L_{A90} noise level, depending on the acoustic characteristics of the plant, as assessed 1 m in front of any noise sensitive facades (see Appendix C).

4 MEASUREMENTS

4.01 Environmental noise measurements were carried out over a weekday period, between approximately 0925 hours on Tuesday 20th December 2016 and concluded 1305 hours the following day, to establish the existing noise levels at the site. The survey methodology and results are set out below.

4.02 Noise measurements have been carried out at the following position, as shown in Appendix B and described as:

- Position 1: located at outside 1st floor window on the north-western elevation of South Wing Building. The measurement was not located within 3.5 metres of any reflecting surfaces, other than the mounting façade.

4.03 The noise climate at the measurement location was dominated by the local and distant noise traffic and mechanical services plant located in a lightwell along the north-western elevation of the South Wing building.

4.04 The measurement location was located outside the closest most affected noise sensitive windows by the proposed plant, described in Section 2.04, and as such it is considered to be representative of these windows.

4.05 The weather during the survey was suitable for outdoor noise measurements, it being dry with little wind for the whole duration of the survey.

5 EQUIPMENT

5.01 The equipment used for the survey was as follows:-

- 01dB Metravib Black Solo Integrating Sound Level Meter conforming to Class 1 BS EN 61672, Type 1 BS EN 60804 & BS EN 60651: 1994;
- 01dB Metravib MCE 212 Condenser Microphone, PRE 21 S Pre-amp and Connecting Leads;
- 01dB Outdoor Microphone Kit and a
- Tripod.

5.02 The equipment holds current UKAS or equivalent accreditation and serial numbers as follows:

Sound Level Meter 01dB Black Solo	Serial No.	61719
	Calibration Date	5th May 2016
	Cal Certificate No.	U21536
½" MCE 212 Condenser Mic.	Serial No.	166397
	Calibration Date	5th May 2016
	Cal Certificate No.	21535
Calibrator CAL 21	Serial No.	34344442
	Calibration Date	5th May 2016
	Cal. Certificate No.	U21534

N.B. Copies of calibration certificates are available upon request.

5.03 The equipment was calibrated both before and after the survey with no difference noted in the levels.

6 RESULTS

6.01 A list of the levels measured is included in Appendix D and represented graphically in Appendix E.

6.02 A summary of the time averaged ambient levels and lowest measured background levels over the measurement periods are shown in Table 6.1. A -3 dB façade correction has been applied to the measured levels to nullify the effect of reflections from the closest façade and thus to represent free-field conditions. The minimum L_{A90} is the lowest five-minute measurement in the specified period.

Position	Period	Average $L_{Aeq,T}$ – dB	Minimum $L_{A90,5min}$ – dB
1	Day time (0700-1900 hrs)	55	49
	Evening (1900-2300 hrs)	51	48
	Night-time (2300-0700 hrs)	51	47

Table 6.1: Free-field measured ambient and lowest background noise levels. The results include a -3 dB façade correction with respect to the measured levels.

7 PLANT ASSESSMENT

7.01 In the following, the impact of noise from the proposed items of plant on the most affected noise sensitive receptors is assessed.

7.02 The proposed plant items are as follows:

- 1 No. Mitsubishi PUHZ-ZRP50VKA condenser, manufactures published Sound Pressure Level (SPL) of 46 dB(A) at 1 m when heating.
- 2 No. Mitsubishi PUMY-P200YKM condensers, manufactures published Sound Pressure Level (SPL) of 61 dB(A) at 1 m each when heating.
- 6 No. Nuaire XBC45-H-NES air handling units (AHU), with the manufacturer's published Sound Power Levels (SWLs) as shown in Table 7.1 below.

Source	63	125	250	500	1k	2k	4k	8k
Open Discharge	85	78	82	68	69	69	63	61
Open Intake	80	72	72	61	61	59	51	42
Open Supply	84	77	82	68	69	68	63	59
Open Extract	81	72	73	60	61	60	50	41
Breakout	71	62	59	44	42	41	37	26

Table 7.1 Manufacturer's published Sound Power Levels (dB) in octave bands (Hz) for the Nuaire XBC45-H-NES unit.

7.03 The units will only be operational during the daytime, between 0700-1900 hours.

Note manufacturers published noise data for the condensers are included in Appendix F

7.04 Noise limits have been set for the proposed plant in accordance with the requirements of LBCC. Consideration has been given to the acoustic characteristics of the proposed plant. In this instance, the proposed units do not display characteristics whereby a more stringent LBCC's criterion of at least 10 dB below the lowest measured background noise levels should be applied. The noise limits have therefore been set to be at least 5 dB below the lowest measured $L_{A90,5min}$ in the relevant period, as shown in Table 7.2 below.

Location	Period	Measured Existing $L_{A90,5min}$ - dB	Proposed Noise Limit L_{Ar} - dB
Position 1	Day-time (0700-1900 hours)	49	44

Table 7.2: Proposed plant noise emission limit based on lowest measured $L_{A90,5min}$.

7.05 Assuming the proposed items meet the noise limits set out in Table 7.2 the noise impact from the plant operation will be approaching the No Observed Effect Level (NOEL) with respect to the NPPF.

7.06 Within our acoustic assessment we have proposed that acoustic lining is installed along sections of the closest façade to the proposed condensers order to nullify the effect of reflections from this façade.

Furthermore, the exhausts of the AHU units will be fitted with in-line attenuation providing 9 dB noise reduction.

7.07 Resultant noise levels have been calculated at the most affected noise sensitive windows described in Section 2.04. Other noise sensitive receptors located further from the site will be subject to lower noise levels than those predicted at these windows.

7.08 Tables 7.3-7.5 further below present the results of worst-case plant noise predictions at the worst-case locations.

7.09 It can be seen from Table 7.6 that the proposed noise limits will be met, provided that the noise control measures described in Section 7.06 above are implemented.

7.10 With respect to the NPPF, achieving the noise limits would be classified as approaching the NOEL.

Item	Noise Level	Notes
1 No. PUHZ-ZRP50VKA 2 No. PUMY-P200YKM	64 dB(A)	Cumulative Sound Pressure Level (SPL) at 1m
Reflections	0 dB	Effect of reflections from the closest façade nullified by acoustic lining
Conformal area losses over 20 metres	-22 dB	Distance to closest window
Resultant noise level	42 dB(A)	SPL at the most affected window

Table 7.3: Worst-case heat recovery unit (HRU) calculation.

Item	Noise Level	Notes
AHU: 2 No. XBC45-H-NES units – exhaust (to west)	80 dB(A)	Cumulative, In-duct SWL
EEC noise control	- 9 dB	Noise reduction provided by in-line attenuation
Spherical spreading losses over 25 metres	- 39 dB	Distance to closest window
Duct losses	- 6 dB	Duct losses including 70° off-axis directivity
Resultant noise level	31 dB(A)	SPL at the most affected window
AHU: 2 No. XBC45-H-NES unit – inlet (roof)	70 dB(A)	Cumulative, In-duct SWL
Spherical spreading losses over 26 metres	- 39 dB	Distance to closest window
Directivity	- 7 dB	Duct losses including 70° off-axis directivity
Resultant noise level	24 dB(A)	SPL at the most affected window
Total noise level	32 dB(A)	Cumulative SPL at the most affected window (west AHUs)

Table 7.4: Worst-case eastern air handling unit (AHU) calculations.

Item	Noise Level	Notes
AHU: 4 No. XBC45-H-NES units – exhaust (to centre)	83 dB(A)	Cumulative, In-duct SWL
EEC noise control	- 9 dB	Noise reduction provided by in-line attenuation
Spherical spreading losses over 25 metres	- 39 dB	Distance to closest window
Reflections	+ 6 dB	Additional reflections facades of East and West sides of building
Directivity	- 6 dB	Duct losses including 70° off-axis directivity
Resultant noise level	35 dB(A)	SPL at the most affected window
AHU: 4 No. XBC45-H-NES unit – inlet (roof)	73 dB(A)	In-duct SWL
Spherical spreading losses over 26 metres	- 39 dB	Distance to closest window
Directivity	- 7 dB	Duct losses including 70° off-axis directivity
Resultant noise level	27 dB(A)	SPL at the most affected window
Total noise level	36 dB(A)	Cumulative SPL at the most affected window (east AHUs)

Table 7.5: Worst-case western air handling unit (AHU) calculations.

Property	Period	Proposed Noise Limit L_{Ar} - dB	Predicted $L_{Aeq,T}$ - dB			Exceedance of noise limit – dB
			Condensers	AHUs	Total	
Most affected window	Daytime (0700-1900 hours)	44	42	37	43	- 1

Table 7.6: Assessment of predicted noise levels based on proposed noise limits.

8 CONCLUSIONS

8.01 Environmental Equipment Corporation Limited has been commissioned by Fowler Martin to undertake an assessment of the noise impact from new mechanical services plant to serve a teaching facility that is proposed to be constructed within the Main Quad of University College London, Gower Street, London.

8.02 The assessment has been carried out in accordance with relevant standards, national planning guidance and the requirements of London Borough of Camden Council (LBCC), and included an environmental noise survey conducted at the site over a typical mid-week period.

8.03 The potential noise impact of the plant has been evaluated at the most affected noise sensitive receptors. Predictions have shown that the noise from the plant will meet the standards requirements of LBCC, provided that acoustic lining is installed on section of the closest façade of the proposed building to the condenser plant to nullify the effect of reflections from this façade, and that at the discharge ductwork of the AHU's an inline noise control solution is fitted providing 9 dB of noise attenuation.

8.04 On the basis of this assessment it is considered that noise should not pose a material constraint to the operation of the proposed plant.

APPENDIX A

GLOSSARY OF TECHNICAL TERMS

TECHNICAL TERMS AND UNITS

Decibel (dB) - This is the unit used to measure sound. The human ear has an approximately logarithmic response to sound over a very large dynamic range (typically 20 micro-Pascals to 100 Pascals). We therefore use a logarithmic scale to describe sound pressure levels, intensities and power levels. The logarithms used are to base 10; hence, an increase of 10 dB in sound pressure level corresponds to a doubling in perceived loudness of the sound.

Sound Power Level (SWL) - This is a function of the noise source alone and is independent of its surroundings. It is a measure of the amount of sound power output measured in decibels.

Sound Pressure Level (SPL) - This is a function of the source and its surroundings and is a measure of the sound pressure at a point in space. For example, a sound pressure level measured at 1 metre from a sound source of certain sound power in reverberant room will not be the same as the sound pressure level a 1 metre from the sound source measured in open space.

Octave and One-Third Octave Bands - The human ear is sensitive to sound over a range of approximately 20 Hz to 20 KHz and is generally more sensitive to medium and high frequencies than to low frequencies. In order to define the frequency content of a noise, the spectrum is divided into frequency bands and the sound pressure level is measured in each band. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For finer analysis, each octave band may be split into one-third octave bands.

"A" Weighting - A number of frequency weightings have been developed to imitate the ear's varying sensitivity to sound of different frequencies. The most commonly used weighting is the "A" weighting. The "A" weighted SPL can be measured directly or derived from octave or one-third octave band SPLs. The result is a single figure index which gives some idea of the subjective loudness of the sound, but which contains no information as to its frequency content.

Noise Rating (NR) Curves - The "A" weighted sound pressure level cannot be used to define a spectrum or to compare sounds of different frequencies. NR curves convey frequency information in a single-figure index. This is done by defining the maximum permissible sound pressure level at each frequency for each curve. To measure the noise rating of a given environment, the SPL is measured in octave or one-third octave bands and the noise rating is then the highest NR curve touched by the measured levels.

Intermittency and Time-Weighting - The degree of annoyance caused by a noise also depends on its duration and intermittency of a noise. Intermittent, impulsive or repetitive noises tend to be more annoying than continuous noises. Various time-weightings have been derived to measure sounds of differing intermittences and these can be measured directly on modern equipment. The most common time-weightings in use are as follows:-

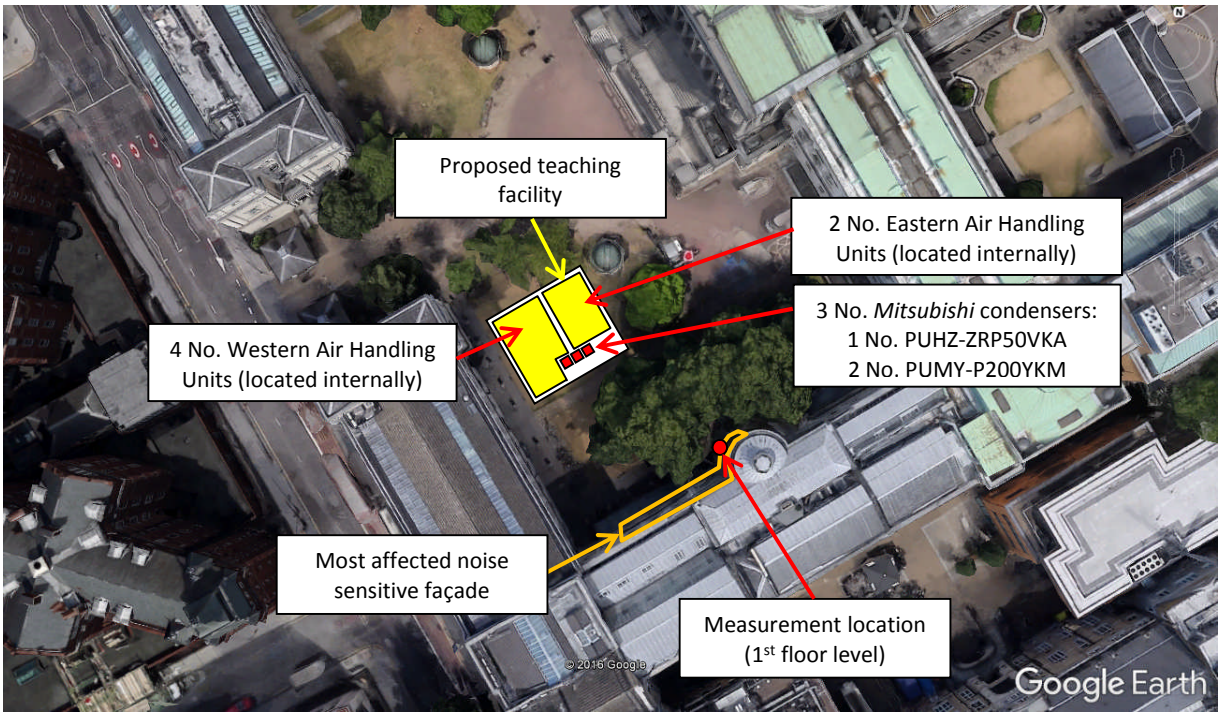
L_{90} This is the sound pressure level exceeded for 90% of the measurement period. It is widely used to measure background noise levels.

L_{10} This is the sound pressure level exceeded for 10% of the measurement period. It is widely used to measure traffic noise. For a given measurement period, the L_{10} level is by definition greater than or equal to the L_{90} level.

L_{eq} The equivalent continuous noise level is often used to measure intermittent noise. It is defined as the notional steady noise level that would contain the same acoustic energy as the varying noise. Because the averaging process used is logarithmic, the L_{eq} level tends to be dominated by the higher noise levels measured.

APPENDIX B

SITE PLAN
&
MEASUREMENT LOCATION



APPENDIX C

PLANNING POLICY AND GUIDANCE

PLANNING POLICY AND GUIDANCE

Planning Policy in the London Borough of Camden

DP POLICY

DP28 – Noise and vibration

The Council will seek to ensure that noise and vibration is controlled and managed and will not grant planning permission for:

a) development likely to generate noise pollution; or

b) development sensitive to noise in locations with noise pollution, unless appropriate attenuation measures are provided.

Development that exceeds Camden's Noise and Vibration Thresholds will not be permitted.

The Council will only grant permission for plant or machinery if it can be operated without cause harm to amenity and does not exceed our noise thresholds.

The Council will seek to minimise the impact on local amenity from the demolition and construction phases of development. Where these phases are likely to cause harm, conditions and planning obligations may be used to minimise the impact.

With relation to plant noise emissions, DP28 provides the following table which sets maximum noise criterion limits above which planning permission will not be granted. The policy explains that noise sensitive development includes housing, schools and hospitals as well as offices.

Table E: Noise levels from plant and machinery at which planning permission will not be granted

Noise description and location of measurement	Period	Time	Noise level
Noise at 1 metre external to a sensitive façade	Day, evening and night	0000-2400	5dB(A) <LA90
Noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) at 1 metre external to a sensitive façade.	Day, evening and night	0000-2400	10dB(A) <LA90
Noise that has distinct impulses (bangs, clicks, clatters, thumps) at 1 metre external to a sensitive façade.	Day, evening and night	0000-2400	10dB(A) <LA90
Noise at 1 metre external to sensitive façade where LA90>60dB	Day, evening and night	0000-2400	55dB$L_{Aeq'}$

National Planning Policy Framework and the Noise Policy Statement for England

The Department for Communities and Local Government published the National Planning Policy Framework (NPPF) on 27th March 2012 and upon its publication, the majority of planning policy statements and guidance notes were withdrawn, including Planning Policy Guidance 24 Planning and Noise, which previously presented the government's overarching planning policy on noise.

The NPPF contains four aims, which are set out at paragraph 123 in Section 11 of the document, titled *Conserving and enhancing the natural environment*:

> *"Planning policies and decisions should aim to:*
>
> *avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;*
>
> *mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;*
>
> *recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and*
>
> *identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason."*

The Department for Environment Food and Rural Affairs published the Noise Policy Statement for England (NPSE) in March 2010. The explanatory note of NPSE defines the following terms used in the NPPF:

> *"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.*
>
> *2.21 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."*

The NPSE does not define any of the above effect levels numerically.

The NPSE presents the Noise Policy Aims as:

> *"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy and sustainable development:*
>
> *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."*

It can be seen that the first two bullet points are similar to Section 11 of the NPPF, with a third aim that seeks to improve health and quality of life. The NPSE later expands on the Noise Policy Aims, stating:

> *2.23 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development (paragraph 1.8).*
>
> *2.24 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development (paragraph 1.8). This does not mean that such adverse effects cannot occur.*
>
> *2.25 This aim* (the third aim)*, seeks where possible, positively to improve health and quality of life through the pro-active management of noise while also taking into account the guiding principles of sustainable development (paragraph 1.8), recognising that there will be opportunities for such measures to be taken and that they will deliver potential benefits to society. The protection of quiet places and quiet times as well as the enhancement of the acoustic environment will assist with delivering this aim."*

It is clear that noise described in the NPSE as SOAEL that would lead to significant adverse effects should be avoided, although there is no definition as to what constitutes a significant adverse effect. Similarly, noise should be mitigated where it is high enough to lead to adverse effects, termed the LOAEL, but not so high that it leads to significant adverse effects.

British Standard 4142

To assess the acceptability of the resultant noise levels we have consulted the relevant standards. BS 4142:2014 'Methods for rating and assessing industrial and commercial sound' has been used to assess the likelihood any adverse impacts based on the resultant noise level from the new plant item, including any corrections for the character of the noise against the existing background noise level.

BS4142 gives guidance on assessing the likelihood of adverse impacts by calculating a 'rating level' of the new noise source and comparing its magnitude at noise sensitive locations to the existing or underlying background noise level. The background noise level is subtracted from the 'rating level' to assess the likelihood of complaints:

- The greater the difference the greater the likelihood of complaints.
- A difference of around +10dB or more is an indication of a significant adverse impact, depending on the context.
- A difference of +5dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background noise level, the less likely it is that the specific sound source will have an adverse impact or 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 sound impact, depending on the context.

This assessment is carried out over a one hour period for the daytime and a fifteen minute period for the night-time. For the purposes of the standard it states that daytime and night-time are typically 07:00 to 23:00 hours and 23:00 to 07:00 hours respectively.

The 'rating level' of the noise source is obtained taking the following factors into consideration:

- The new plant noise (the specific noise) is measured or predicted in terms of L_{Aeq}.
- An additional correction shall be included if the noise contains a distinguishable, discrete continuous note, if the noise contains distinct impulses or if the noise is irregular enough to attract attention. The value for any tonal noise can be an addition of up to 6dB and for impulsive noise of up to 9dB.

BS 4142 goes onto state that:

'The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context.'

BS4142 has been referenced in setting noise limits for any fixed plant proposed as part of the proposed development.

APPENDIX D

SURVEY RESULTS
(TABULAR)

EC 15170 - UCL Main Quad

Fowler Martin

Tabulated Noise data

Time	L_{Aeq}	L_{AMax}	L_{A90}
09:25	57	70	54
09:30	57	68	53
09:35	56	72	53
09:40	57	68	53
09:45	60	77	53
09:50	58	71	53
09:55	55	62	53
10:00	55	66	52
10:05	56	71	53
10:10	57	72	53
10:15	57	72	54
10:20	55	64	53
10:25	57	73	53
10:30	56	67	53
10:35	55	63	53
10:40	58	68	53
10:45	56	73	53
10:50	55	67	53
10:55	54	63	52
11:00	55	61	53
11:05	55	59	52
11:10	56	72	53
11:15	56	64	53
11:20	55	61	53
11:25	57	64	52
11:30	55	61	53
11:35	54	61	53
11:40	55	69	53
11:45	56	65	54
11:50	55	67	53
11:55	56	66	53
12:00	57	69	53
12:05	56	67	54
12:10	55	62	53
12:15	55	70	53
12:20	61	74	53
12:25	54	61	52
12:30	55	66	52
12:35	55	67	53
12:40	55	61	53
12:45	55	66	53
12:50	55	61	53
12:55	56	73	53
13:00	55	61	54
13:05	56	63	54
13:10	56	65	54
13:15	55	62	54
13:20	57	78	54

Time	L_{Aeq}	L_{AMax}	L_{A90}
13:25	56	63	54
13:30	56	66	54
13:35	57	71	54
13:40	56	62	54
13:45	56	65	54
13:50	57	68	54
13:55	57	67	55
14:00	57	65	55
14:05	56	66	53
14:10	56	62	53
14:15	56	66	53
14:20	55	64	53
14:25	56	68	54
14:30	55	63	53
14:35	56	70	53
14:40	56	64	54
14:45	56	63	54
14:50	57	71	54
14:55	57	73	53
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15:05	56	67	54
15:10	57	67	54
15:15	57	71	54
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15:55	61	74	58
16:00	61	69	58
16:05	61	67	59
16:10	62	71	59
16:15	63	69	59
16:20	61	66	59
16:25	61	68	58
16:30	60	69	57
16:35	60	66	56
16:40	61	66	58
16:45	59	66	57
16:50	62	73	59
16:55	62	70	58
17:00	61	68	58
17:05	62	69	59
17:10	63	78	60
17:15	60	67	57
17:20	62	70	59

EC 15170 - UCL Main Quad

Fowler Martin

Tabulated Noise data

Time	L_{Aeq}	L_{AMax}	L_{A90}
17:25	61	69	58
17:30	61	70	58
17:35	62	75	58
17:40	62	75	58
17:45	63	78	60
17:50	63	70	60
17:55	63	73	59
18:00	62	69	58
18:05	60	68	58
18:10	60	71	56
18:15	61	67	58
18:20	60	67	57
18:25	61	67	57
18:30	60	66	56
18:35	58	74	54
18:40	55	68	53
18:45	55	67	53
18:50	55	62	53
18:55	54	69	52
19:00	54	63	52
19:05	54	59	52
19:10	54	64	51
19:15	55	65	52
19:20	54	66	51
19:25	53	64	51
19:30	55	77	51
19:35	54	64	51
19:40	54	70	51
19:45	53	56	51
19:50	53	62	51
19:55	54	70	51
20:00	54	68	51
20:05	53	58	51
20:10	54	66	51
20:15	53	58	51
20:20	54	59	52
20:25	54	74	52
20:30	54	58	52
20:35	53	57	52
20:40	55	63	52
20:45	54	67	52
20:50	57	76	51
20:55	53	60	51
21:00	53	59	51
21:05	53	56	51
21:10	59	75	52
21:15	54	58	52
21:20	54	64	52

Time	L_{Aeq}	L_{AMax}	L_{A90}
21:25	54	65	52
21:30	54	62	52
21:35	54	60	52
21:40	54	60	51
21:45	54	67	52
21:50	54	70	51
21:55	58	70	52
22:00	54	58	52
22:05	54	58	52
22:10	54	62	51
22:15	54	69	52
22:20	56	74	51
22:25	54	64	52
22:30	53	64	51
22:35	53	61	51
22:40	54	58	52
22:45	54	59	51
22:50	54	59	51
22:55	54	58	51
23:00	53	58	51
23:05	54	65	51
23:10	54	62	51
23:15	53	59	51
23:20	53	57	51
23:25	53	57	51
23:30	53	57	51
23:35	53	57	51
23:40	54	60	51
23:45	53	59	51
23:50	53	58	51
23:55	53	59	51
00:00	53	68	51
00:05	53	63	51
00:10	53	59	51
00:15	53	59	51
00:20	53	58	51
00:25	54	60	52
00:30	53	58	51
00:35	53	58	51
00:40	53	57	51
00:45	52	57	50
00:50	52	57	50
00:55	53	61	51
01:00	52	65	51
01:05	53	62	51
01:10	52	60	50
01:15	53	57	50
01:20	53	63	50

EC 15170 - UCL Main Quad

Fowler Martin

Tabulated Noise data

Time	L_{Aeq}	L_{AMax}	L_{A90}
01:25	53	57	51
01:30	53	59	51
01:35	52	65	50
01:40	52	57	51
01:45	53	59	51
01:50	52	59	50
01:55	52	58	50
02:00	53	63	51
02:05	53	65	50
02:10	53	64	50
02:15	56	76	51
02:20	53	59	50
02:25	51	55	50
02:30	52	62	50
02:35	52	64	50
02:40	52	58	50
02:45	56	75	51
02:50	53	63	51
02:55	54	67	50
03:00	52	59	50
03:05	53	60	50
03:10	53	65	51
03:15	63	85	51
03:20	54	64	51
03:25	52	59	51
03:30	53	60	50
03:35	53	58	50
03:40	52	57	51
03:45	52	57	50
03:50	52	59	50
03:55	52	57	50
04:00	53	61	51
04:05	54	70	51
04:10	52	58	51
04:15	53	60	51
04:20	53	59	51
04:25	52	58	51
04:30	52	57	51
04:35	54	61	51
04:40	52	64	51
04:45	54	65	51
04:50	54	59	52
04:55	54	69	51
05:00	53	59	51
05:05	54	61	51
05:10	54	60	51
05:15	54	63	51
05:20	59	74	51

Time	L_{Aeq}	L_{AMax}	L_{A90}
05:25	54	69	51
05:30	54	62	52
05:35	54	66	51
05:40	61	78	53
05:45	54	65	51
05:50	53	69	51
05:55	54	59	51
06:00	53	58	51
06:05	56	66	52
06:10	59	67	53
06:15	53	60	51
06:20	56	70	52
06:25	54	66	52
06:30	57	64	53
06:35	55	67	52
06:40	55	66	52
06:45	55	66	52
06:50	56	67	52
06:55	55	72	52
07:00	56	67	53
07:05	63	87	57
07:10	60	77	56
07:15	56	72	52
07:20	54	65	52
07:25	57	74	52
07:30	55	65	53
07:35	55	61	53
07:40	55	64	53
07:45	56	73	53
07:50	56	70	53
07:55	56	65	53
08:00	56	75	53
08:05	57	72	53
08:10	56	64	53
08:15	56	68	53
08:20	56	63	53
08:25	56	61	54
08:30	56	64	53
08:35	56	65	53
08:40	56	63	53
08:45	56	65	53
08:50	56	65	54
08:55	57	69	54
09:00	56	70	54
09:05	57	64	54
09:10	57	66	54
09:15	56	64	53
09:20	58	73	54

EC 15170 - UCL Main Quad

Fowler Martin

Tabulated Noise data

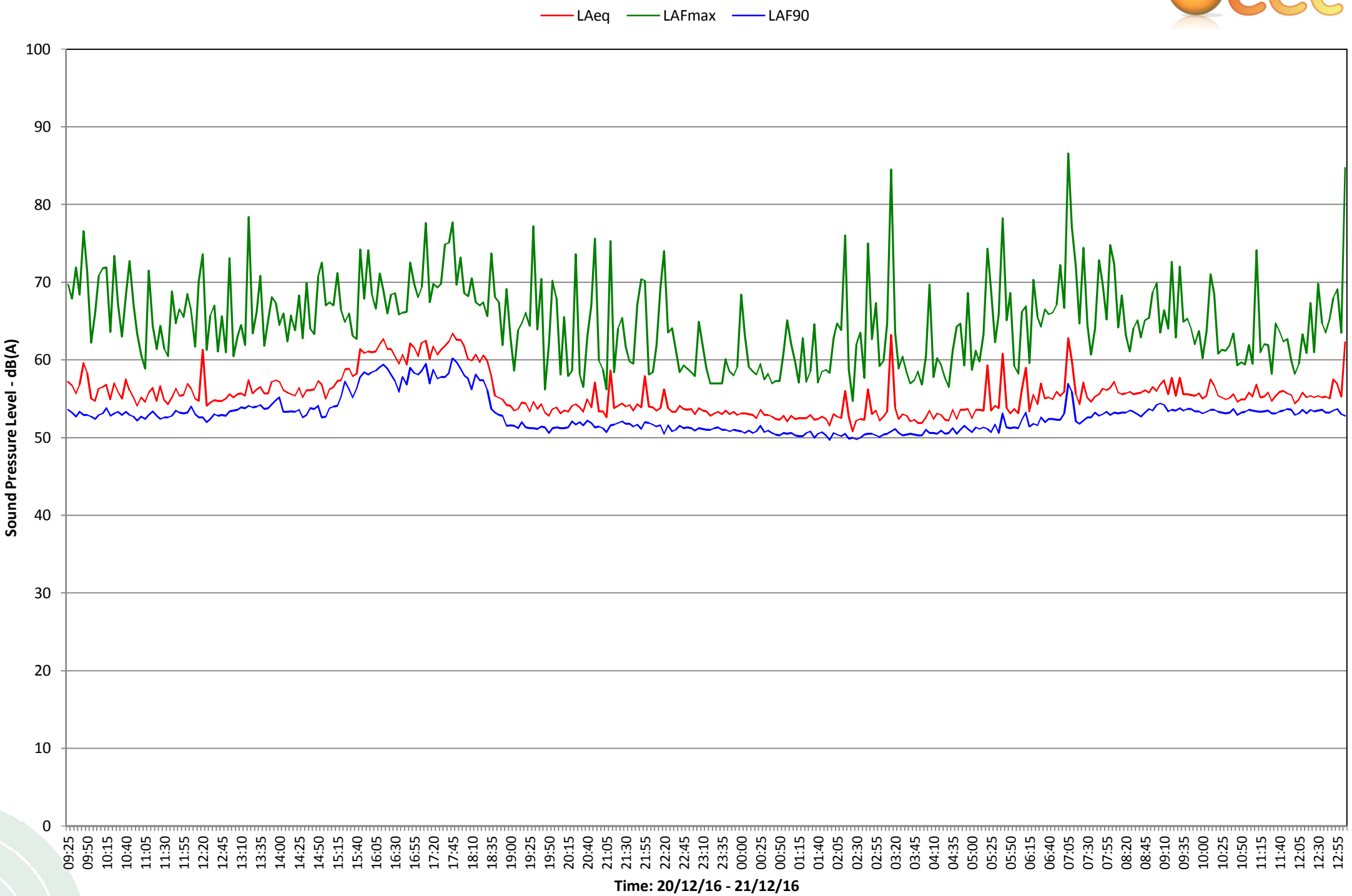
Time	L_{Aeq}	L_{AMax}	L_{A90}
09:25	*55*	*63*	*54*
09:30	*58*	*72*	*54*
09:35	*56*	*65*	*54*
09:40	*56*	*65*	*54*
09:45	*56*	*64*	*54*
09:50	*55*	*62*	*53*
09:55	*56*	*64*	*53*
10:00	*55*	*60*	*53*
10:05	*55*	*64*	*53*
10:10	*58*	*71*	*54*
10:15	*57*	*69*	*54*
10:20	*55*	*61*	*53*
10:25	*55*	*61*	*53*
10:30	*55*	*61*	*53*
10:35	*55*	*62*	*53*
10:40	*56*	*63*	*54*
10:45	*55*	*59*	*53*
10:50	*55*	*60*	*53*
10:55	*55*	*59*	*53*
11:00	*56*	*62*	*54*
11:05	*55*	*60*	*54*
11:10	*57*	*74*	*53*
11:15	*55*	*61*	*53*
11:20	*55*	*62*	*53*
11:25	*56*	*62*	*54*
11:30	*55*	*58*	*53*
11:35	*55*	*65*	*53*
11:40	*56*	*64*	*53*
11:45	*56*	*62*	*54*
11:50	*56*	*63*	*54*
11:55	*56*	*60*	*54*
12:00	*54*	*58*	*53*
12:05	*55*	*60*	*53*
12:10	*56*	*63*	*54*
12:15	*55*	*61*	*53*
12:20	*55*	*67*	*54*
12:25	*55*	*61*	*53*
12:30	*55*	*70*	*54*
12:35	*55*	*65*	*54*
12:40	*55*	*64*	*53*
12:45	*55*	*65*	*53*
12:50	*58*	*68*	*54*
12:55	*57*	*69*	*54*
13:00	*55*	*64*	*53*
13:05	*62*	*85*	*53*

Time	L_{Aeq}	L_{AMax}	L_{A90}

APPENDIX E

SURVEY RESULTS
(GRAPHICAL)

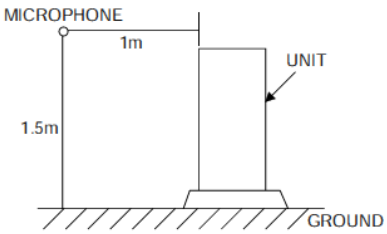
Noise Level Time History at UCL Main Quad



APPENDIX F

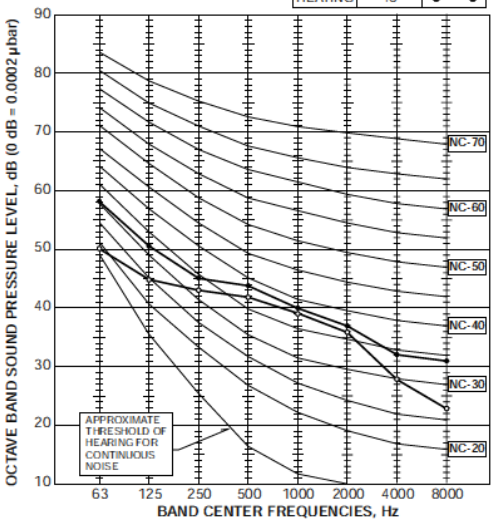
PUBLISHED PLANT NOISE DATA

5-3. NOISE CRITERION CURVES



PUHZ-ZRP35VKA
PUHZ-ZRP50VKA

MODE	SPL(dB)	LINE
COOLING	44	
HEATING	46	



4-5. NOISE CRITERION CURVES

PUMY-P200YKM
PUMY-P200YKM-BS

MODE	SPL(dB)	LINE
COOLING	56	
HEATING	61	
COOLING SILENT MODE	53