Buro Happold

Wellcome Collection Development Project

Planning and Noise Report

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author	**Serafino Di Rosario CEng MIOA**
signature	
date	**18/01/2013**
approved	**Ian Thompson MSc MIOA**
signature	
date	**18/01/2013**

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Glossary

Term	Definition
Acoustics	(1) the science of sound; (2) of a room: those factors which determine its character with respect to the quality of the received sound.
Airborne sound	sound or noise radiated directly from a source, such as a loudspeaker or machine, into the surrounding air (in contrast to structure-borne sound).
Airborne sound insulation	the reduction or attenuation of airborne sound by a solid partition between source and receiver; this may be a building partition, e.g. a floor, wall or ceiling, a screen or barrier or an acoustic enclosure.
Ambient noise	the totally encompassing noise in a given situation at a given time; it is usually composed of noise from many sources, near and far (defined in BS 4142).
Background noise level $L_{A90,T}$	The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 % of a given time interval, T, measured using time weighting, F, and quoted to the nearest whole number of decibels.
Equivalent continuous noise level	of a time-varying noise; the steady noise level (usually in dB(A)) which, over the period of time under consideration, contains the same amount of (A-weighted) sound energy as the time-varying noise over the same period of time
Free field	Where a measurement has been conducted at a distance of at least 3.5m away from the nearest reflecting façade or surface
Frequency response	of measurement system or component of such a system, e.g. a sound level meter or microphone; the variation in performance, e.g. sensitivity, with change of frequency.
Frequency spectrum	a graph resulting from a frequency analysis and showing the different levels of the signal in the various frequency bands.
Frequency weighting	an electronic filter built into a sound level meter according to BS 5969. (A weighting – a frequency weighting devised to attempt to take into acc9ount the fact that human response to sound is not equally sensitive to all frequencies; it consists of an electronic filter in a sound level meter, which attempts to build in this variability into the indicated noise level reading so that it will correlate, approximately, with human response.) (C weighting – one of the frequency weightings defined in BS 5969 (IEC 651; it corresponds to the 100-phon contour and is the closest to the linear or unweighted value.)
Noise Rating NR	Noise rating (NR) curves are commonly used in Europe for specifying noise levels from mechanical services in order to control the character of the noise.
Percentile level, $L_{AN,T}$	the sound level, in dB(A) which is exceeded for *N%* of the time interval *T*, for example in L_{A10} and L_{A90}.
***Q* factor**	a quantity which measures the sharpness of the resonance of a single degree of freedom mechanical or electrical vibrating system; in a mechanical system it is related to the damping ratio, the amplification produced at resonance and the shape of the resonance peak.
Reflection	the redirection of waves which occurs at a boundary between media when the size of the boundary interface is large compared with the wavelength.
Refraction	the change in direction of waves caused by changes in the wave velocity in the medium
Transmission loss	a measure of the airborne sound insulating properties, in a particular frequency band, of a material in the form of a panel or partition, or of a building element such as a well, window or floor; it is measured in decibels: $R = 10 \log_{10} (1/t)$, where *t* is the sound transmission coefficient; it is measured under laboratory conditions according to BS 2750; also known as sound reduction index, *R*.
Time weighting	one of the standard averaging times (F, S, I) used for the measurement of RMS sound pressure level in sound level meters, specified in BS 5969.
Weighted sound reduction index, R_W	a single-figure value of sound reduction index, derived according to procedures given in BS 5821, used for rating and comparing partitions and based on the values of sound reduction index at different frequencies.

Executive Summary

This report presents an assessment of the existing environmental noise levels for the environment surrounding the Wellcome Collection Building, London. The report details noise levels at nearest noise sensitive buildings and an assessment of current noise level emissions from existing plant.

The assessment has been based on environmental noise survey data obtained in June 2012 and in December 2012 (24 Hrs).

Based on measurement, a representative value for the lowest predevelopment background noise level at the nearest noise sensitive property for night time would be 59dB L_{A90}.

Provided that noise emissions from the proposed plant are limited to teh values provided by the MEP designers and shown in Table 5 then;

- The proposed installation will meet the requirements set out in DP28;
- And be at a level compared to background that is of marginal significance when considering the likelihood of complaints in accordance with BS4142.

If noise from the proposed fixed plant contains tonal qualities or has an impulsive characteristic, then a further 5dB reduction penalty will be applied to the design limits.

1 Introduction

Buro Happold Limited has been instructed to conduct an environmental noise assessment in connection with proposals for refurbishment works at the Wellcome Collection, 183 Euston Road. The proposed work will include the installation of new building services equipment including roof top plant. The rooftop plant could be in operation for 24 hours a day and 7 days a week.

This report provides an assessment of the noise level limits for new fixed plant that will service the Wellcome Collection. The limits are set in order to protect residential amenity in the nearest noise sensitive properties.

The following information is included within the report:

- A summary of noise data obtained at the nearest noise sensitive property
- A summary of noise data of existing equipment located on the roof of the Wellcome Trust building
- Assessment of the noise level limits for emissions from the equipment and associated noise control measures required for compliance with London Borough of Camden's (LBC) Policy DP28 – Noise and Vibration.
- An assessment of the likelihood of noise compliant in accordance with BS4142.

2 Standards, principles and reference information

The following standards were adopted in the environmental noise survey:

- BS7445:2003: Description and measurement of environmental noise – Part 1: Guide to quantities and procedures.

The following standards and principles were adopted in the assessment:

- BS4142:1997: Method for Rating industrial noise affecting mixed residential and industrial areas.
- BS EN ISO 3746:1996 Acoustics – Determination of sound power levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane.

The following material was used as reference for the survey:

- London Borough of Camden (LBC) Policy DP28 – Noise and Vibration.

3 Site and environmental noise climate

3.1 Site

The Wellcome Collection building is located at 183 Euston Road, Camden. The site is adjacent to Euston Road to the North, Gordon Street to the East and Gower Place to the South. The Wellcome Trust occupies 215 Euston Road, which is the adjacent building to the West of 183 Euston Road. The nearest noise sensitive building is John Adams Hall located on Endsleigh Gardens and Euston Square Hotel, 152-156 North Gower Street. Both buildings are approximately 100m from the Wellcome Collection building at 183 Euston Road.

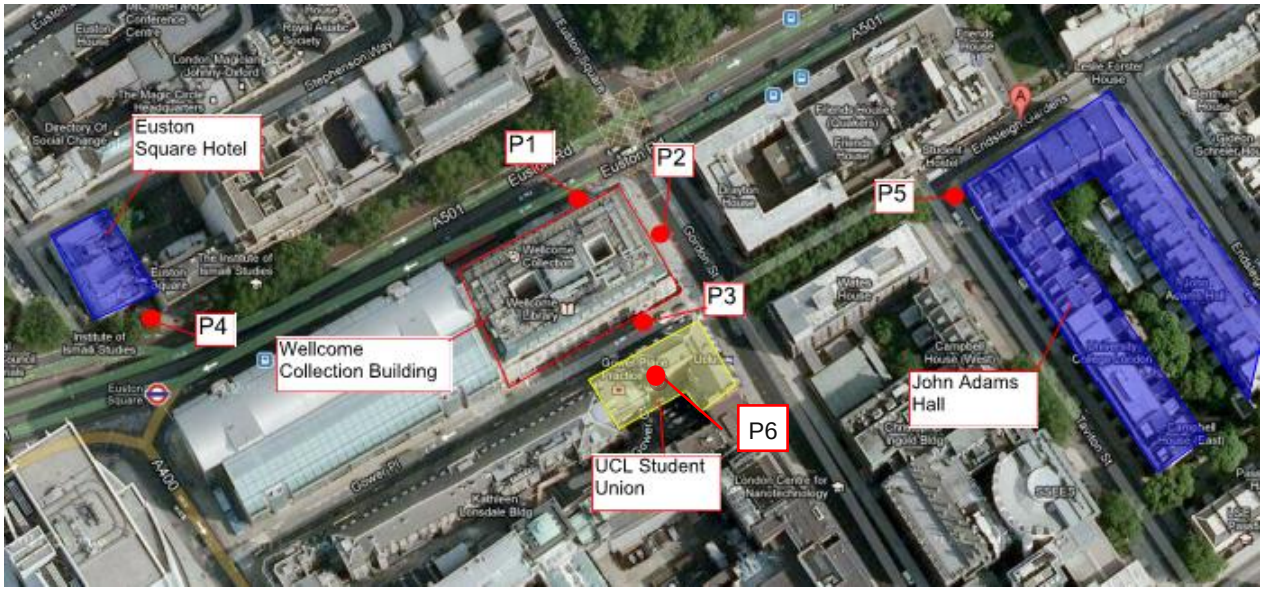


Figure 1: Site plan and measurement locations

The dominant noise sources are traffic on Euston Road and Gordon Street. Other noise sources include sirens, noise associated with building services plant, pedestrians and distant overhead aircraft.

3.2 Baseline noise survey

Buro Happold conducted an environmental noise survey on 13th June 2012 at approximately 15:50 to 16:15. Additional measurements were conducted on 20th June 2012 between 15:25 to16:20 and 21st June 2012 between 02:35 to 03:25.

After a review by Camden Council on the Pre Application documentation, Buro Happold has been requested to perform an additional 24 hrs survey at the nearest sensitive facade; measurement point P6 identifies the location of the survey that was conducted on 20 December 2012 from 00:00 to 21 December 2012 00:00 on the flat rooftop of Kathleen Lonsdale Building by the edge facing the Wellcome Trust roof plant area.

The weather conditions were favourable with no rain and wind conditions were noted at the location to be less than 3m/s in any direction for all measurements. Measurement locations are indicated on Figure 1.

3.3 Equipment and methodology

The equipment used in the survey was as follows;

- Sound level meter: Brüel & Kjær 2260 Investigator Serial number 2466988
- Microphone: GRAS-40AE Serial number 132918
- Calibrator: Brüel & Kjær 4231 Serial number 2438725
- Tripod
- Anemometer

The sound level meter was calibrated prior and after the measurement with no significant deviation across the period of the survey (approximately 0.02dB).

The methodology followed guidance described *in BS7445:2003 Description and measurement of environmental noise – Part 1: Guide to quantities and procedures*.

Day time measurements durations were a combination of 5 minute and 15 minute periods. Night time measurements were conducted at locations of nearest noise sensitive properties for 5 minute periods.

These durations are considered sufficient to be representative of typical events for the locations and to align with the requirements of the standards for assessment.

5 locations were chosen for the environmental noise survey as described below and marked on Figure 1.

Position	Description	Measurement field descriptor	Dominant noise sources
P1	Euston road – Near north façade of Wellcome Trust	Daytime Free field	Traffic on Euston road, Pedestrians, Sirens
P2	Gordon Street – Near east façade of Wellcome Trust	Daytime Free field	Traffic on Gordon Street and Euston road, Pedestrians, Sirens
P3	Gower Place – Near south façade of Wellcome Trust	Daytime Free field	Traffic on Gower Place and Gordon Street, Pedestrians, Sirens, noise from building service equipment
P4	Euston Road – Outside Euston Square Hotel	Night time Free field	Traffic on Euston road, Pedestrians
P5	Endsleigh Gardens- Outside John Adams student accommodation	Night time Free field	Traffic on Endsleigh Gardens and Euston road, Pedestrians, Noise from building services equipment.
P6	Kathleen Lonsdale Building Rooftop on the edge facing Wellcome Trust building	Daytime + Night time Free Field and Facade	Traffic on Gordon street and Gower place, Pedestrians, Noise from building services equipment.

Table 1: Description of measurement locations

3.4 Results

The following table summarises the day time and night time results for the spot measurement (rounded to the nearest decibel).The table contains the lowest measured value for the L_{Amin} & L_{A90}, and the highest measured value for the L_{A10}, L_{Amax} and the L_{Aeq}.

		Day time measured sound levels, dB re 2 x 10^{-5} Pa				
Position	**Duration in minutes**	**LAeq**	**LAminS**	**LAmaxS**	**LA90**	**LA10**
P1	15	74	63	88	67	77
P2	15	71	66	81	68	73
P3	15	70	62	83	63	72
P6	960 (16 Hrs)	64	-	-	59	-
		Night time measured sound levels, dB re 2 x 10^{-5} Pa				
Position	**Duration in minutes**	**LAeq**	**LAminF**	**LAmaxF**	**LA90**	**LA10**
P4	5	77	54	97	56	78
P5	5	61	52	75	53	61
P6	480 (8 hrs)	62	-	-	59	-

Table 2: Summary of results from environmental noise survey

The following summarises the results for the noise levels from existing roof top plant on the Wellcome Collection building.

	Octave band centre frequency, Hz							**A wtd**	**NR**
Measurement location & plant	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**		
Chiller location A	71	70	70	72	70	66	55	74	70
Chiller location B	72	71	68	67	62	61	47	68	64
Chiller location C	89	85	80	77	74	70	65	80	74
1m from AHU intake (AHU1)	79	73	62	56	54	50	46	61	58
1m from AHU exhaust (AHU2)	80	81	69	65	62	60	61	70	67
1m from AHU exhaust casing (AHU2)	79	77	72	71	71	70	67	76	72
1m from AHU exhaust (AHU3)	88	79	66	62	62	60	50	68	66
AHU – Air Handling Unit									

Table 3: Measured noise levels from existing roof top plant

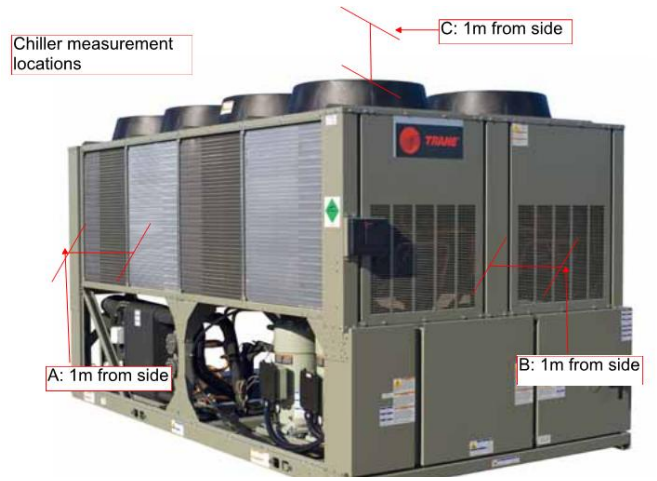


Figure 2: Chiller measurement locations

(Note – Chiller in the diagram is not the same model as installed on the roof)

4 Planning policy and assessment method

4.1 Planning policy

The proposed refurbishment works for The Wellcome Collection are expected to be subject to planning conditions and policies as detailed in the LBC's Local Development Framework.

(LDF). Development Policy 28 (DP28) is related to noise and vibration associated with planning proposals:

Camden's Core Strategy recognises the importance of this issue for Camden's residents and policy DP28 contributes to implementing a number of Core Strategy policies, including CS5 - Managing the impact of growth and development, CS9 - Achieving a successful Central London, CS11 - Promoting sustainable and efficient travel and CS16 - Improving Camden's health and well-being.

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.

A condition will be imposed to require that the plant and equipment which may be a source of noise pollution is kept working efficiently and within the required noise limits and time restrictions. Conditions may also be imposed to ensure that attenuation measures are kept in place and effective throughout the life of the development.

Specific objective requirements for planning proposals that contain noise generating plant and machinery are detailed in Table E of the LDF;

Noise description and location of measurement	Period	Time	Noise level
Noise at 1 metre external to a sensitive façade	Day, evening and night	00:00-24:00	5dB(A)<L_{A90}
Noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) at 1 metre external to a sensitive façade.	Day, evening and night	00:00-24:00	10dB(A)<L_{A90}
Noise that has distinct impulses (bangs, clicks, clatters, thumps) at 1 metre external to a sensitive façade.	Day, evening and night	00:00-24:00	10dB(A)<L_{A90}
Noise at 1 metre external to sensitive façade where LA90>60dB	Day, evening and night	00:00-24:00	55dB $L_{Aeq,T}$

Table 4: LBC requirements for noise emissions from any new proposed plant

4.2 BS 4142

BS 4142 is a British Standard describing a method for assessing the likelihood of disturbance caused by industrial noise, or industrial type noise from a commercial premise, affecting a mixed use area.

Although the building considered is not for industrial use, it is an accepted method to use the principle behind the standard for rating the likelihood of disturbance caused by fixed plant associated with the refurbishment works. The assessment is based upon the difference between the rating level of the specific noise source and the existing background noise level.

Section 9 of the Standard provides the following guidance for assessment:

> *Assess the likelihood of complaints by subtracting the measured background noise level from the rating level.*
>
> *(NOTE. More than one assessment may be appropriate.)*
>
> *The greater this difference the greater the likelihood of complaints.*
>
> *A difference of around +10 dB or more indicates that complaints are likely.*
>
> *A difference of around + 5 dB is of marginal significance.*
>
> *If the rating level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.*

The 'rating level' used in the assessment will include a penalty of 5dB if one or more of the following features occur, or are expected to be present for new or modified noise sources:

- The noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.);

The noise contains distinct impulses (bangs, clicks, clatters, or thumps);

- The noise is irregular enough to attract attention.

5 Limiting sound pressure levels for new fixed plant installations

5.1 Day time limit for noise levels at nearest noise sensitive buildings

The nearest noise sensitive building for day time periods is the UCL student union building on Gordon Street. The building contains a façade facing Gower Place approximately 24m from the Wellcome Collection building.

The lowest background noise level at this location was established as 59dB L_{A90}.

The total rating noise level for the plant is 58dB L_{Aeq} for the plant at UCL union.

Based on treating the air handling units (AHU) exhausts as point sources and chiller noise propagation as a conformal surface in accordance with BS EN ISO 3746:1996, the associated noise level at the façade from the existing equipment is 58dB L_{Aeq}.

5.2 Night time limit for noise levels at nearest noise sensitive buildings

The nearest noise sensitive buildings for night time periods are John Adams student halls accommodation and Euston Square Hotel. These are both approximately 100m from the Wellcome Trust building.

The lowest background noise level at Euston Square Hotel was established as 56dB L_{A90}. The associated total rating noise level for noise emissions from plant to Euston Square Hotel is 53dB L_{Aeq}.

Based on treating the AHU exhausts as point sources and chiller noise propagation as conformal surface in accordance with BS EN ISO 3746:1996, the associated noise level at the façade from the existing equipment is 49dB L_{Aeq}.

The lowest background noise level at John Adams Hall was established as 53dB L_{A90}. The associated total rating noise level for noise emissions from plant to Euston Square Hotel is 48dB L_{Aeq}.

Based on treating the AHU exhausts as point sources and chiller noise propagation as conformal surface in accordance with BS EN ISO 3746:1996, the associated noise level at the façade from the existing equipment is 44dB L_{Aeq}. This prediction assumes a 5dB reduction from screening.

5.3 Noise control considerations for the refurbishment works

The design will need to ensure that noise from new building services equipment does not exceed the limits described in section 5.1 and 5.2 at existing noise sensitive buildings.

The exact specification, type, number and location of new building services equipment has been finalised and transmitted by Max Fordham MEP designer to Buro Happold.

The current design shows the following new plant installations:

1. Thematic Gallery Dehumidifier – Munters MX55
2. Thematic Gallery AHU - comprised of two sections – Flaktwoods (top deck 1.25 m3/s and bottom deck 4.0 m3/s)
3. Kitchen supply AHU - not specified by Max Fordham – Flaktwoods (3.5 m3/s)

4. Kitchen Extract fan – Flaktwoods 80JM.BIF(200)
5. New Toilet Extract Fan (replaces existing) - no selection yet for this but it will be very similar to the existing unit; assumed same sound pressure level to surroundings, not included in the calculation of future scenario noise levels.

Noise levels with the associated new equipment are shown in tab below:

	SWL - Octave band centre frequency, Hz							A wtd	
Measurement location & plant	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**		
Thematic Gallery Dehumidifier	88	89	83	87	83	77	75	88	
Thematic Gallery AHU – Top Deck	55	62	57	43	38	37	32	51	
Thematic Gallery AHU – Bottom Deck	64	69	56	48	48	44	40	56	
Kitchen Supply AHU	62	63	73	53	48	50	43	65	
Kitchen Extract Fan	88	100	92	94	93	88	83	97	

Table 5: New equipment Sound Power Level

Calculation for sound pressure level generated by new installed plants at the nearest noise sensitive location for day time period and at the nearest noise sensitive building for night-time period has been performed and included in Appendix B.

This will result in predicted noise levels at nearest noise sensitive facades of;

- 54dB $L_{Aeq,T}$ at UCL student union
- 45dB $L_{Aeq,T}$ at Euston Square Hotel
- 40dB $L_{Aeq,T}$ at John Adams Halls

It should be noted that within this assessment, it is assumed that all new equipment will be operational.

The predicted noise levels calculated above satisfies the limits specified in London Borough of Camden's (LBC) Policy DP28 – Noise and Vibration and in Table 4 (5 dB < LA90).

5.4 Recommendations and Conclusions

Calculation of the sound pressure level of newly installed fixed plant and equipment associated with the Wellcome Collection refurbishment shows that the proposals will:

- Satisfy the requirements of LBC LDF requirements set out in DP28
- And be at a level where there is an indication that complaints are of marginal significance in accordance with BS4142.

Where the proposed equipment would generate higher sound pressure levels, compared to the values provided by the designer, the scheme for fixed plant installation will need to incorporate additional acoustic mitigation measures, for example acoustic screening or enclosure of equipment

.

Appendix A Environmental noise data

Day time measurements:

Table 6: Daytime measurement results, dB re $2x10^{-5}$ Pa

Position	File	Start time	Duration, mins	Octave band frequency in Hz								A wtd	LA max	LA min	LA90
				63	125	250	500	1k	2k	4k	8k				
P1	45	15:26	15	84	77	72	70	68	66	65	61	74	88	63	67
P2	46	15:44	15	81	73	70	67	66	64	60	54	71	81	66	68
P3	47	16:02	15	78	73	67	66	64	63	58	52	69	83	62	63

Night time measurements:

Table 7: Night time measurement results, dB re $2x10^{-5}$ Pa

Position	File	Start time	Duration, mins	Octave band frequency in Hz								A wtd	LA max	LA min	LA90
				63	125	250	500	1k	2k	4k	8k				
P4	48	02:37	5	78	71	69	69	76	68	59	50	77	97	58	61
P5	50	02:51	5	66	62	59	57	57	52	45	39	61	75	53	54
P4	51	02:58	5	75	70	67	66	68	63	55	47	71	81	54	56
P5	52	03:06	5	64	59	56	52	51	45	37	27	55	66	52	53
P4	53	03:14	5	76	67	68	67	69	64	56	47	72	84	55	58
P5	54	03:22	5	64	60	57	53	53	47	39	35	57	68	53	53

24 Hrs measurements:

Table 8: 24 Hrs measurement results, dB re $2x10^{-5}$ Pa

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
Start time	23:55	75	63.37	61.42
20/12/12	00:00	70.3	61.06	59.12
20/12/12	00:05	78.27	63.07	59.32
20/12/12	00:10	66.13	61.21	59.32
20/12/12	00:15	65.96	60.78	59.07
20/12/12	00:20	68.57	61.05	58.76
20/12/12	00:25	76.62	62.36	59.77
20/12/12	00:30	70.15	62.19	59.32
20/12/12	00:35	65.23	60.92	58.87
20/12/12	00:40	65.47	60.73	58.9

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	00:45	64.88	60.84	59.05
20/12/12	00:50	65.22	61.08	59.15
20/12/12	00:55	66.8	61.37	59.35
20/12/12	01:00	68.25	61.76	59.58
20/12/12	01:05	67.57	61.98	59.63
20/12/12	01:10	69.54	61.82	59.73
20/12/12	01:15	67.34	61.66	59.78
20/12/12	01:20	68.24	62.13	59.87
20/12/12	01:25	79.92	62.36	59.66
20/12/12	01:30	66.3	61.42	59.63
20/12/12	01:35	66.64	60.8	58.99
20/12/12	01:40	64.91	60.73	58.88
20/12/12	01:45	74.85	62.07	59.03
20/12/12	01:50	66.3	60.65	58.6
20/12/12	01:55	69.66	60.76	58.99
20/12/12	02:00	68	60.63	58.45
20/12/12	02:05	68.09	60.34	58.33
20/12/12	02:10	64.99	60.38	58.38
20/12/12	02:15	63.87	60.34	58.76
20/12/12	02:20	68.11	61.41	59.22
20/12/12	02:25	65.76	60.75	59.21
20/12/12	02:30	67.18	60.74	59.04
20/12/12	02:35	69.47	61.51	58.94
20/12/12	02:40	66.92	60.42	58.47
20/12/12	02:45	65.75	60.12	58.37
20/12/12	02:50	73.75	62.14	59.16
20/12/12	02:55	64.69	60.7	59.42
20/12/12	03:00	67.92	60.69	58.74
20/12/12	03:05	65.09	59.98	58.29
20/12/12	03:10	66.58	60.04	58.33
20/12/12	03:15	69.13	59.54	58.14
20/12/12	03:20	65.18	60.17	58.32
20/12/12	03:25	63.34	59.65	58.11
20/12/12	03:30	82.88	63.34	58.27
20/12/12	03:35	67.8	60	58.46
20/12/12	03:40	68.75	60.91	58.51
20/12/12	03:45	67.82	60.92	59.02
20/12/12	03:50	63.76	60.46	59.1
20/12/12	03:55	66.54	60.79	59.34
20/12/12	04:00	64.09	60.6	59.18
20/12/12	04:05	73.84	62.58	58.7

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	04:10	65.5	59.95	58.17
20/12/12	04:15	66.08	59.85	58.16
20/12/12	04:20	64.43	60	58.29
20/12/12	04:25	63.33	59.65	57.97
20/12/12	04:30	63.92	59.56	58.14
20/12/12	04:35	67.1	60.37	58.12
20/12/12	04:40	66.93	62.22	58.84
20/12/12	04:45	69.51	61.36	58.89
20/12/12	04:50	66.73	61.22	58.73
20/12/12	04:55	70.64	61.14	58.83
20/12/12	05:00	74.35	61.59	58.84
20/12/12	05:05	66.16	60.7	58.61
20/12/12	05:10	64.87	60.1	58.41
20/12/12	05:15	72.05	61.86	58.98
20/12/12	05:20	65.96	61.42	59.05
20/12/12	05:25	69.44	60.85	58.87
20/12/12	05:30	85.8	65.09	60.31
20/12/12	05:35	86.77	63.64	58.8
20/12/12	05:40	67.36	60.48	58.5
20/12/12	05:45	64.89	60.3	58.63
20/12/12	05:50	65.31	60.95	58.96
20/12/12	05:55	68.91	62.55	60.5
20/12/12	06:00	65.63	63.98	63.32
20/12/12	06:05	68.35	64.24	63.19
20/12/12	06:10	70.83	64.29	63.21
20/12/12	06:15	67.35	64.15	63.28
20/12/12	06:20	69.16	64.13	63.22
20/12/12	06:25	66.42	64.03	63.26
20/12/12	06:30	68.05	64.44	63.53
20/12/12	06:35	68.1	64.49	63.72
20/12/12	06:40	76.17	65.55	63.69
20/12/12	06:45	68.81	64.71	63.75
20/12/12	06:50	67.94	64.65	63.82
20/12/12	06:55	71.78	64.72	63.82
20/12/12	07:00	69.79	64.76	63.62
20/12/12	07:05	66.94	64.52	63.83
20/12/12	07:10	68.3	64.62	63.34
20/12/12	07:15	71.01	65.57	64.23
20/12/12	07:20	72.78	64.91	63.48
20/12/12	07:25	77.91	65.76	64.2
20/12/12	07:30	68.63	64.75	63.87

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	07:35	69.76	64.72	64.03
20/12/12	07:40	68.92	64.82	64.1
20/12/12	07:45	74.11	65.69	64.23
20/12/12	07:50	67.79	64.54	63.81
20/12/12	07:55	76.95	65.12	63.85
20/12/12	08:00	76.98	67.52	64.44
20/12/12	08:05	68.92	64.84	63.68
20/12/12	08:10	68.62	64.88	64.02
20/12/12	08:15	76.55	65.65	64.14
20/12/12	08:20	69.82	65.13	64.24
20/12/12	08:25	70.15	65.49	64.48
20/12/12	08:30	67.92	64.64	63.73
20/12/12	08:35	68.98	65.14	64.26
20/12/12	08:40	74.08	65.25	64.02
20/12/12	08:45	67.83	64.93	63.96
20/12/12	08:50	68.45	65.42	64.33
20/12/12	08:55	78.51	67.01	64.53
20/12/12	09:00	69.74	65.32	64.51
20/12/12	09:05	69.21	64.86	64
20/12/12	09:10	80.11	66.12	64.01
20/12/12	09:15	68.39	64.89	63.71
20/12/12	09:20	73.11	65.75	64.11
20/12/12	09:25	69.12	65.17	64.26
20/12/12	09:30	67.62	64.92	64.09
20/12/12	09:35	67.29	64.55	63.72
20/12/12	09:40	69.08	64.62	63.82
20/12/12	09:45	68.62	64.67	63.88
20/12/12	09:50	81.84	67.62	64.04
20/12/12	09:55	73.49	65.97	64.14
20/12/12	10:00	69.55	64.67	63.92
20/12/12	10:05	69.81	64.79	63.73
20/12/12	10:10	71.79	65.35	63.82
20/12/12	10:15	70.31	64.96	64
20/12/12	10:20	78.27	65.74	64.34
20/12/12	10:25	76.96	65.67	64.05
20/12/12	10:30	73.19	65.87	63.97
20/12/12	10:35	72.34	65.25	63.96
20/12/12	10:40	71.24	65.61	64.18
20/12/12	10:45	67.73	64.7	63.91
20/12/12	10:50	67.92	64.66	63.86
20/12/12	10:55	76.15	65.43	64.14

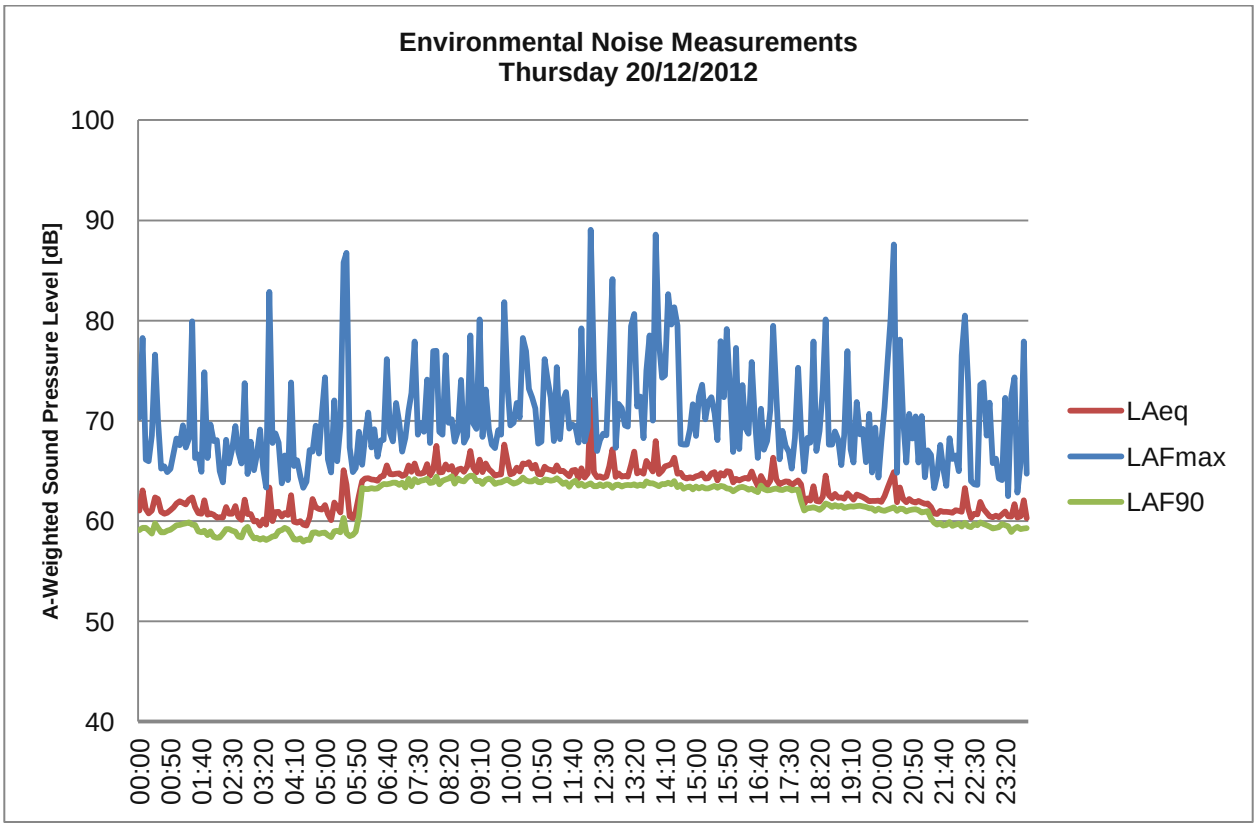
Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	11:00	74.19	65.19	64.12
20/12/12	11:05	72.33	65.12	64.03
20/12/12	11:10	67.97	64.96	64.1
20/12/12	11:15	75.35	65.57	64.27
20/12/12	11:20	68.19	64.99	64.01
20/12/12	11:25	72.1	65	63.7
20/12/12	11:30	72.88	64.77	63.87
20/12/12	11:35	69.24	64.47	63.41
20/12/12	11:40	69.65	65.04	63.83
20/12/12	11:45	69.44	65.11	64.03
20/12/12	11:50	67.83	64.28	63.54
20/12/12	11:55	79.21	65.28	63.75
20/12/12	12:00	67.94	64.34	63.48
20/12/12	12:05	69.39	64.75	63.65
20/12/12	12:10	89.07	72.08	63.76
20/12/12	12:15	75.06	64.84	63.48
20/12/12	12:20	66.98	64.39	63.47
20/12/12	12:25	68.09	64.48	63.66
20/12/12	12:30	68.72	64.32	63.49
20/12/12	12:35	68.56	64.45	63.66
20/12/12	12:40	75.77	65.45	63.63
20/12/12	12:45	84.15	67.14	63.32
20/12/12	12:50	67.32	64.42	63.61
20/12/12	12:55	71.68	64.76	63.65
20/12/12	13:00	71.26	64.45	63.45
20/12/12	13:05	69.55	64.51	63.59
20/12/12	13:10	69.42	64.45	63.6
20/12/12	13:15	79.46	65.59	63.57
20/12/12	13:20	80.65	66.92	63.68
20/12/12	13:25	71.43	64.75	63.5
20/12/12	13:30	72.42	64.98	63.63
20/12/12	13:35	68.28	64.74	63.52
20/12/12	13:40	75.01	65.99	63.97
20/12/12	13:45	78.51	65.49	63.76
20/12/12	13:50	70.04	64.96	63.78
20/12/12	13:55	88.58	67.97	63.64
20/12/12	14:00	77.95	64.71	63.48
20/12/12	14:05	74.3	65.01	63.71
20/12/12	14:10	74.54	65.45	63.67
20/12/12	14:15	82.63	65.55	63.82
20/12/12	14:20	79.62	65.69	63.67

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	14:25	81.32	66.33	63.99
20/12/12	14:30	79.52	64.74	63.38
20/12/12	14:35	67.71	64.83	63.6
20/12/12	14:40	67.64	64.39	63.24
20/12/12	14:45	67.64	64.25	63.39
20/12/12	14:50	69.12	64.38	63.44
20/12/12	14:55	71.67	64.29	63.17
20/12/12	15:00	68.5	64.46	63.44
20/12/12	15:05	72.42	64.55	63.27
20/12/12	15:10	73.62	64.76	63.43
20/12/12	15:15	70.16	64.24	63.26
20/12/12	15:20	71.88	64.29	63.26
20/12/12	15:25	72.36	64.77	63.38
20/12/12	15:30	70.75	64.88	63.53
20/12/12	15:35	68.09	64.06	63.31
20/12/12	15:40	77.94	64.79	63.52
20/12/12	15:45	72.37	64.54	63.44
20/12/12	15:50	79.15	64.99	63.25
20/12/12	15:55	73.16	64.93	63.23
20/12/12	16:00	66.89	63.87	62.98
20/12/12	16:05	77.29	64.21	63.16
20/12/12	16:10	67.19	64.07	63.34
20/12/12	16:15	73.57	64.21	63.43
20/12/12	16:20	69.34	64.3	63.32
20/12/12	16:25	68.73	64.22	63.14
20/12/12	16:30	75.88	64.95	63.22
20/12/12	16:35	70.55	64.17	63.03
20/12/12	16:40	66.32	63.5	62.92
20/12/12	16:45	71.22	64.5	63.55
20/12/12	16:50	67.11	63.96	63.18
20/12/12	16:55	67.97	63.54	63.06
20/12/12	17:00	71.04	64.02	63.1
20/12/12	17:05	79.48	66.32	63.18
20/12/12	17:10	72.49	64.14	63.25
20/12/12	17:15	66.18	63.67	63.12
20/12/12	17:20	69.01	63.84	63.09
20/12/12	17:25	67.5	63.95	63.22
20/12/12	17:30	66.89	63.92	63.26
20/12/12	17:35	65.23	63.58	63.08
20/12/12	17:40	68.31	63.82	63.14
20/12/12	17:45	75.3	64.05	63.13

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	17:50	69.07	63.69	62.02
20/12/12	17:55	64.96	61.72	61.07
20/12/12	18:00	68.32	62.27	61.29
20/12/12	18:05	67.83	62.05	61.3
20/12/12	18:10	77.9	63.47	61.38
20/12/12	18:15	66.98	62.02	61.27
20/12/12	18:20	69	61.95	61.12
20/12/12	18:25	73.17	62.44	61.39
20/12/12	18:30	80.13	64.55	61.76
20/12/12	18:35	67.63	62.59	61.62
20/12/12	18:40	67.62	62.28	61.42
20/12/12	18:45	68.93	62.72	61.59
20/12/12	18:50	68.14	62.33	61.44
20/12/12	18:55	65.58	62.37	61.52
20/12/12	19:00	68.6	62.24	61.3
20/12/12	19:05	76.96	62.77	61.42
20/12/12	19:10	67.17	62.45	61.46
20/12/12	19:15	65.84	62.15	61.45
20/12/12	19:20	71.89	62.65	61.5
20/12/12	19:25	68.67	62.52	61.55
20/12/12	19:30	69.2	62.41	61.48
20/12/12	19:35	65.88	62.22	61.41
20/12/12	19:40	70.69	61.98	61.29
20/12/12	19:45	64.85	62.01	61.28
20/12/12	19:50	69.31	62.02	61.04
20/12/12	19:55	64.35	62.03	61.25
20/12/12	20:00	67.93	61.91	61.08
20/12/12	20:05	71.36	62.5	61.04
20/12/12	20:10	76.16	63.34	61.15
20/12/12	20:15	80.25	64.1	61.25
20/12/12	20:20	87.59	64.89	61.38
20/12/12	20:25	64.83	61.89	61.02
20/12/12	20:30	78.12	63.35	61.24
20/12/12	20:35	70.17	62.2	61.22
20/12/12	20:40	65.83	61.88	60.96
20/12/12	20:45	70.7	62.21	61.08
20/12/12	20:50	68.24	61.94	61.15
20/12/12	20:55	70.43	61.86	61.17
20/12/12	21:00	65.85	62.02	61.1
20/12/12	21:05	70.48	61.84	60.85
20/12/12	21:10	64.39	61.73	60.94

Start date	19/12/2012			
Interval	5	L_{AFMax}	L_{Aeq}	L_{AF90}
20/12/12	21:15	67.06	61.77	60.98
20/12/12	21:20	66.61	61.41	60.3
20/12/12	21:25	63.3	60.77	59.85
20/12/12	21:30	64.55	60.72	59.65
20/12/12	21:35	67.59	61.02	59.8
20/12/12	21:40	65.3	60.92	59.56
20/12/12	21:45	63.5	60.93	59.63
20/12/12	21:50	68.27	60.89	59.9
20/12/12	21:55	66.19	60.84	59.53
20/12/12	22:00	66.54	61.1	59.65
20/12/12	22:05	64.97	61.03	59.76
20/12/12	22:10	76.53	60.92	59.45
20/12/12	22:15	80.49	63.29	59.83
20/12/12	22:20	73.83	61.27	59.49
20/12/12	22:25	63.98	60.31	59.41
20/12/12	22:30	63.66	60.75	59.73
20/12/12	22:35	63.6	60.67	59.59
20/12/12	22:40	73.6	61.91	59.86
20/12/12	22:45	73.84	61.21	59.7
20/12/12	22:50	68.52	60.82	59.58
20/12/12	22:55	71.83	60.48	59.47
20/12/12	23:00	65.78	60.37	59.27
20/12/12	23:05	66.22	60.55	59.34
20/12/12	23:10	64.24	60.39	59.39
20/12/12	23:15	64.09	60.68	59.71
20/12/12	23:20	72.31	60.96	59.58
20/12/12	23:25	62.48	60.47	59.49
20/12/12	23:30	72.46	60.44	58.93
20/12/12	23:35	74.35	61.7	59.26
20/12/12	23:40	62.86	60.36	59.44
20/12/12	23:45	65.79	60.48	59.21
20/12/12	23:50	77.93	62.08	59.27
20/12/12	23:55	64.73	60.28	59.29

Figure 3: 24 Hrs measurements, time history, dB re 2x10^{-5} Pa



Appendix B Environmental noise calculations

The following table shows the sound pressure level generated by the newly installed equipment on the Wellcome Trust rooftop plant to the nearest sensitive building for day time prediction for day time period (UCL student Union at 24 m).

NOISE BREAK OUT FROM ROOFTOP PLANT	Frequency								LwA
	63	125	250	500	1000	2000	4000	8000	
Thematic Gallery Dehumidifier -MX55 (Worst case)	88	89	83	87	83	77	75	66	88
Thematic Gallery AHU - top deck (to surroundings=case radiated)	55	62	57	43	38	37	32	32	51
Thematic Gallery AHU - bottom deck (to surroundings=case radiated)	64	69	56	48	48	44	40	38	56
Kitchen Extract fan (Outlet)	88	100	92	94	93	88	83	80	97
New Toilet Extract Fan (replaces existing so data from existing fan)									
Kitchen supply AHU (to surroundings), dB	62	63	73	53	48	50	43	33	65
TOTAL Lw	**91**	**100**	**93**	**95**	**93**	**88**	**84**	**80**	97

Calculations:									
Assume point source radiation									
Nearest sensitive receiver [m]:	24								
formula	Lw-20*log (r) -11+10*log(Q)								
Q=directivity index = 3 dB for hemispherical radiation	3								
	57	67	59	61	60	54	50	46	
A-weighted correction	-26	-16	-9	-3	0	1	1	-1	
A weighted SPL at nearest residential receiver 24 m away	31	51	50	58	60	55	51	45	

Day/night limits measured on Kathleen Lonsdale Building:	LAeq (façade)		LAeq (free-field)		Min LA90		Min LA90 (free-field)	
Date	Day time	Night-time	Day time	Night time	Day time	Night-time	Day time	Night-time
20/12/2012	**64**	**62**	**62**	**59**	**59**	**59**	**57**	**56**

Serafino Di Rosario CEng MIOA
Buro Happold Limited
71 Newman Street
London
W1T 1PD
UK

Telephone: +44(0) 207927 9700
Facsimile: +44(0) 870787 4145
Email: serafino.dirosario@burohappold.com