HEMEL HEMPSTEAD DATACENTRES: ENVIRONMENTAL PERMIT VARIATION APPLICATION

Noise Impact Assessment

Prepared for: NTT Global Data Centers EMEA UK Limited

Client Ref: 410.05391.00011

SLR Ref: 410.05391.00011
Version No: 1
March 2022

BASIS OF REPORT

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1.0 Introduction

NTT Global Data Centers EMEA UK Limited (NTT) has appointed SLR Consulting Ltd. (SLR) to undertake an assessment in relation to an Environmental Permit variation application for their Hemel Hempstead data centre sites comprising Maylands, Centro, Campus and HH4, herein referred to as 'the Site'.

The permit variation application relates specifically to phase 2 of the HH4 data centre. Data centre HH4 Phase 2 will involve the installation and operation of an additional 13 diesel-fired standby generators (SBGs) (model Kohler 2500); this will result in a total of 28 SBGs at HH4, and an overall total of 77 diesel-fired SBGs at the Site. The cumulative effect of all 77 SBGs is addressed in this report.

The SBGs provide power to the data centres in the event that there is an emergency situation such as a brown- or black- out of the local electricity transmission network where there are fluctuations or loss of the electrical power provided by the network.

This noise assessment has been undertaken in accordance with British Standard 4142:2014+A1:2019 '*Methods for rating and assessing industrial and commercial sound*' and is based on the results of spot measurements undertaken on Site and a background sound survey conducted at nearby noise-sensitive receptors (the spot measurements and background noise survey was undertaken in relation to the noise assessment prepared for the original environmental permit application (SLR Report '*413.05391.00002 Noise Assessment*', July 2020).

1.1 Report Structure

This Report presents:

- A description of the Site;
- A description of applicable guidance;
- The results of a baseline background sound survey at locations representative of the nearest noise-sensitive receptors to the proposed new plant;
- Sound modelling software CadnaA® noise level predictions associated with the proposed intensification of operations using the calculation methodologies in ISO 9613-2:1996 '*Acoustics – Attenuation of Sound during Propagation Outdoors– Part 2: General Method of Calculation*'; and,
- An assessment undertaken in accordance with British Standard 4142:2014+A1:2019 '*Methods for rating and assessing industrial and commercial sound*' as required by the Environment Agency (EA) Guidance *Noise and vibration management: environmental permits;*

Whilst reasonable effort has been made to ensure that this report is easy to understand, it is technical in nature; to assist the reader, a glossary of terminology is included in **Appendix 01**.

2.0 Site Description

2.1 Existing Site

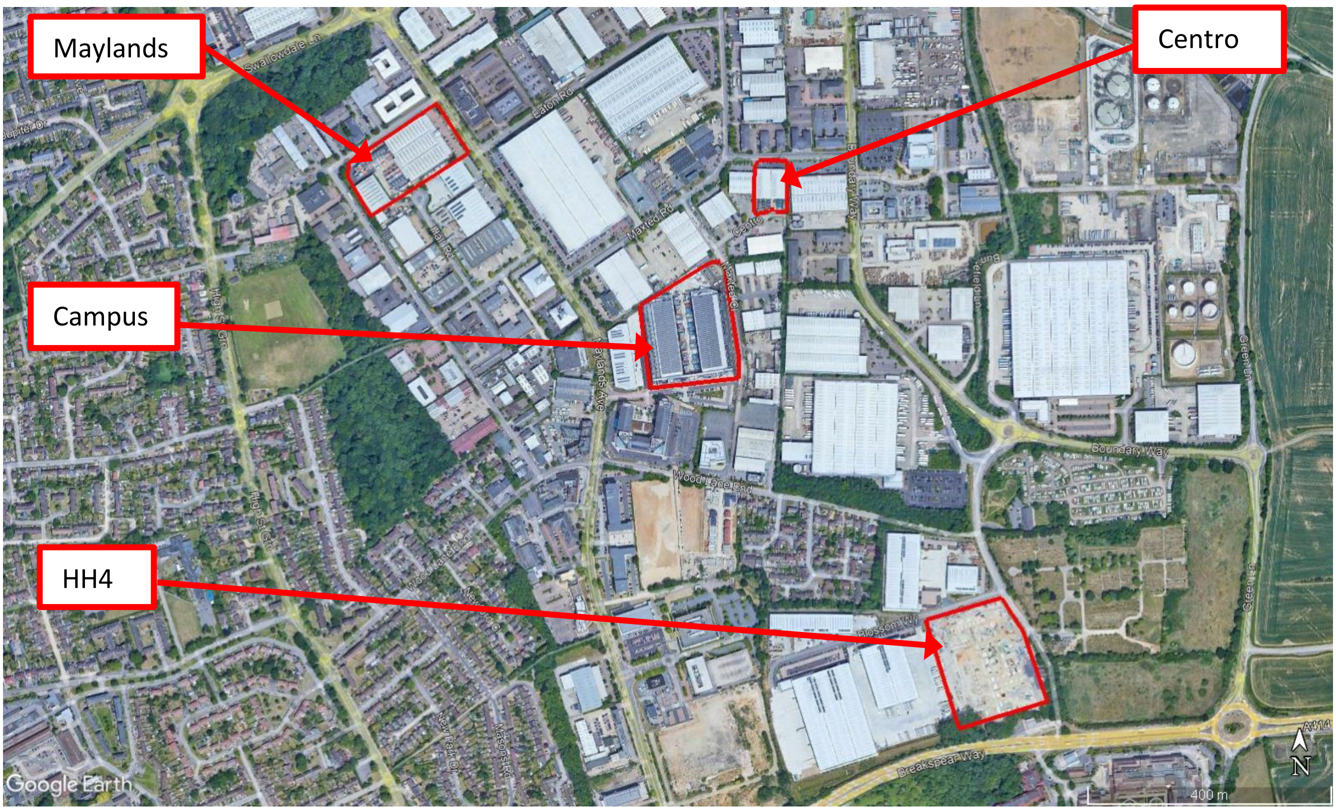
The four datacentres that comprise the Site are located to the northeast of Hemel Hempstead town centre, as shown in Figure 2-1.

The addresses and National Grid Reference coordinates of the four datacentres are detailed in Table 2-1.

Table 2-1
Datacentre Locations

Datacentre	Address	Coordinates (X, Y)*
Campus	Spring Way, Hemel, HP2 7UP	508000, 208180
Centro	3 Boundary Way, Hemel Hempstead HP2 7SU	508131, 208437
Maylands	150 Maylands Avenue, Hemel Hempstead, HP2 7DF	507540, 208473
Hemel Hempstead 4 (HH4)	Prologis Park, Hemel Hempstead, HP2 7EQ	508514, 207662
* Coordinates represent the approximate centre of the main datacentre building at each address, quoted in terms of National Grid References (NGR)		

Figure 2-1
Site Location (Approximate Boundaries Shown in Red)



The nearest noise-sensitive receptors to the site are detailed in Table 2-2

Table 2-2
Identified Noise Sensitive Receptor Locations

Receptor	Comments	Coordinates (X, Y)*
Wood Lane End	Considered to reasonably represent the residential properties on a number of roads off Wood Lane End including Wood End Close, approximately 210 m to the south east of Campus datacentre	508112, 207931
Farmhouse Lane	Considered to reasonably represent the residential properties along Farmhouse Lane, approximately 200 m to the east of the Maylands datacentre	507262, 208345
Crest Park	Considered to reasonably represent the residential properties approximately 170 m to the north west of the HH4 datacentre	508302, 207773
* Quoted in terms of NGR		

2.2 Proposals

The proposals include the installation of 13 no. SBGs at the HH4 site. This will result in, across the four sites:

- 31 no. SBGs at the Campus site
- 4 no. SBGs at the Centro site
- 14 no. SBGs at the Maylands site
- 28 no. SBGs at the HH4 site

The proposed locations of the plant are provided in **Appendix 04**.

3.0 Scope and Guidance

A summary of the requirements outlined in the Environment Agency (EA) guidance document[1], and the assessment methodology outlined in BS4142:2014+A1:2019 are provided below.

3.1 Noise and vibration management: environmental permits

The EA released the guidance document '*Noise and vibration management: environmental permits'* (NVM) in July 2021, replacing the previous guidance presented in '*Horizontal Guidance for Noise (H3) parts 1 and 2'*. The NVM details when a noise assessment is required, the competency required to undertake an assessment and how to carry out a noise impact assessment.

The NVM references BS4142:2014+A1:2019 as the appropriate assessment methodology.

The NVM outlines how context should be taken into account in the assessment and notes that *"Whilst context allows you to interpret impact thresholds (to a degree), there are practical limits to the extent of the interpretation. It is unlikely you could adjust the assessment outcome beyond the next band (for example, modifying a BS 4142 outcome of more than 10dB to be less than an 'adverse impact')."*

The guidance goes on to state that in determining the outcome of the assessment the following should be considered:

- Weekdays rather than weekends.
- What the sound 'means' – meaningful sound is one that conveys an unpleasant meaning beyond its mere acoustic content, for example noise from an abattoir.
- Time of day.
- The absolute sound level.
- Where the sound occurs.
- New industry or new residences.
- Intrinsic links between the source and receptor, for example the source is the resident's place of work.
- Local attitudes.
- The residual acoustic environment.
- The land use at the receptor (for example, gardens rather than yards).
- The exceedance (traditional BS 4142).
- Whatever else might be particular to that individual situation.

Based on the results of the BS4142:2014+A1:2019 assessment the NVM has three distinct requirements as detailed in Table 3-1.

[1] Online guidance document: www.gov.uk/government/publications/noise-and-vibration-management-environmental-permits/

Table 3-1
NVM Assessment

NVM Result	BS4142 Descriptor	Next Stage
Unacceptable level of audible or detectable noise	The closest corresponding BS 4142 descriptor is 'significant adverse impact'	You must take further action or you may have to reduce or stop operations. The environment agencies will not issue a permit if you are likely to be operating at this level.
Audible or detectable noise	The closest corresponding BS 4142 descriptor is 'adverse impact'	Your duty is to use appropriate measures to prevent or, where that is not practicable, minimise noise. You are not in breach if you are using appropriate measures. But you will need to rigorously demonstrate that you are using appropriate measures.
No noise, or barely audible or detectable noise	The closest corresponding BS 4142 descriptor is 'low impact or no impact'	Low impact does not mean there is no pollution. However, if you have correctly assessed it as low impact under BS 4142, the environment agencies may decide that taking action to minimise noise is a low priority.

3.2 British Standard 4142:2014+A1:2019

British Standard 4142:2014+A1:2019 '*Methods for rating and assessing industrial and commercial sound'* is intended to be used to assess the potential adverse impact of sound, of an industrial and/or commercial nature, at nearby noise-sensitive receptor locations within the context of the existing sound environment.

Where the specific sound contains tonality, impulsivity and/or other sound characteristics, penalties should be applied depending on the perceptibility. For tonality, a correction of either 0, 2, 4 or 6 dB should be added and for impulsivity, a correction of either 0, 3, 6 or 9 dB should be added. If the sound contains specific sound features which are neither tonal nor impulsive, a penalty of 3 dB should be added.

In addition, if the sound contains identifiable operational and non-operational periods, that are readily distinguishable against the existing sound environment, a further penalty of 3 dB may be applied.

The assessment of impact contained in BS4142:2014+A1:2019 is undertaken by comparing the sound rating level, i.e. the specific sound level of the source plus any penalties, to the measured representative background sound level immediately outside the noise-sensitive receptor location. Consideration is then given to the context of the existing sound environment at the noise-sensitive receptor location to assess the potential impact.

Once an initial estimate of the impact is determined, by subtracting the measured background sound level from the rating sound level, BS4142:2014+A1:2019 states that the following should be considered:

- typically, the greater the difference, the greater the magnitude of the impact;
- a difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context;
- a difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context; and
- 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. It is an indication that the specific sound source has a low impact, depending on the context.

BS4142:2014+A1:2019 notes that:

"Adverse impacts include, but are not limited to, annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact."

BS4142:2014+A1:2019 outlines guidance for the consideration of the context of the potential impact including consideration of the existing residual sound levels, location and/or absolute sound levels.

To account for the acoustic character of proposed sound sources, BS4142:2014+A1:2019 provides the following with respect to the application of penalties to account for *"the subjective prominence of the character of the specific sound at the noise-sensitive locations and the extent to which such acoustically distinguishing characteristics will attract attention".*

- **Tonality** – *"For sound ranging from not tonal to predominantly tonal the Joint Nordic Method gives a correction of between 0dB and +6dB for tonality. Subjectively, this can be converted to a penalty of 2dB for a tone which is just perceptible at the noise receptor, 4dB where it is clearly perceptible and 6dB where it is highly perceptible;*
- **Impulsivity** – *A correction of up to +9dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3dB for impulsivity which is just perceptible at the noise receptor, 6dB where it is clearly perceptible, and 9dB where it is highly perceptible;*
- **Intermittency** – *When the specific sound has identifiable on/off conditions, the specific sound level ought to be representative of the time period of length equal to the reference time interval which contains the greatest total amount of on time. If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied; and*
- **Other Sound Characteristics** – *Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3dB can be applied."*

Finally, BS4142:2014+A1:2019 outlines guidance for the consideration of the context of the potential impact, including consideration of the existing residual sound levels, location and/or absolute sound levels.

3.3 ISO 9613-2:1996

The levels of sound generated by the operation of the proposed plant has been predicted in accordance with the prediction framework within ISO 9613-2:1996 *Acoustics – Attenuation of Sound during Propagation Outdoors– Part 2: General Method of Calculation*. This method of calculation takes into account the distance between the sound sources and the closest receptors, and the amount of attenuation due to atmospheric absorption. The methodology also assumes downwind propagation, i.e. a wind direction that assists the propagation of sound from the source to the receiver.

4.0 Baseline Sound Survey

4.1 Survey Dates

To determine baseline sound levels in the vicinity of the identified nearby noise sensitive receptors to the site, a noise survey was undertaken between Thursday 18th July 2019 and Tuesday 23rd July 2019. The noise levels measured during this period were used for the original environmental permit application. These noise levels are considered to be appropriate for use in the environmental permit variation application for HH4 Phase 2 on the basis that the wider site and the locations of the nearby receptors have not changed significantly since the original survey.

4.2 Weather Conditions

During the survey, weather conditions were generally suitable for noise monitoring. A summary of the weather conditions for the duration of the noise survey during daytime and night-time periods is provided in Table 4-1.

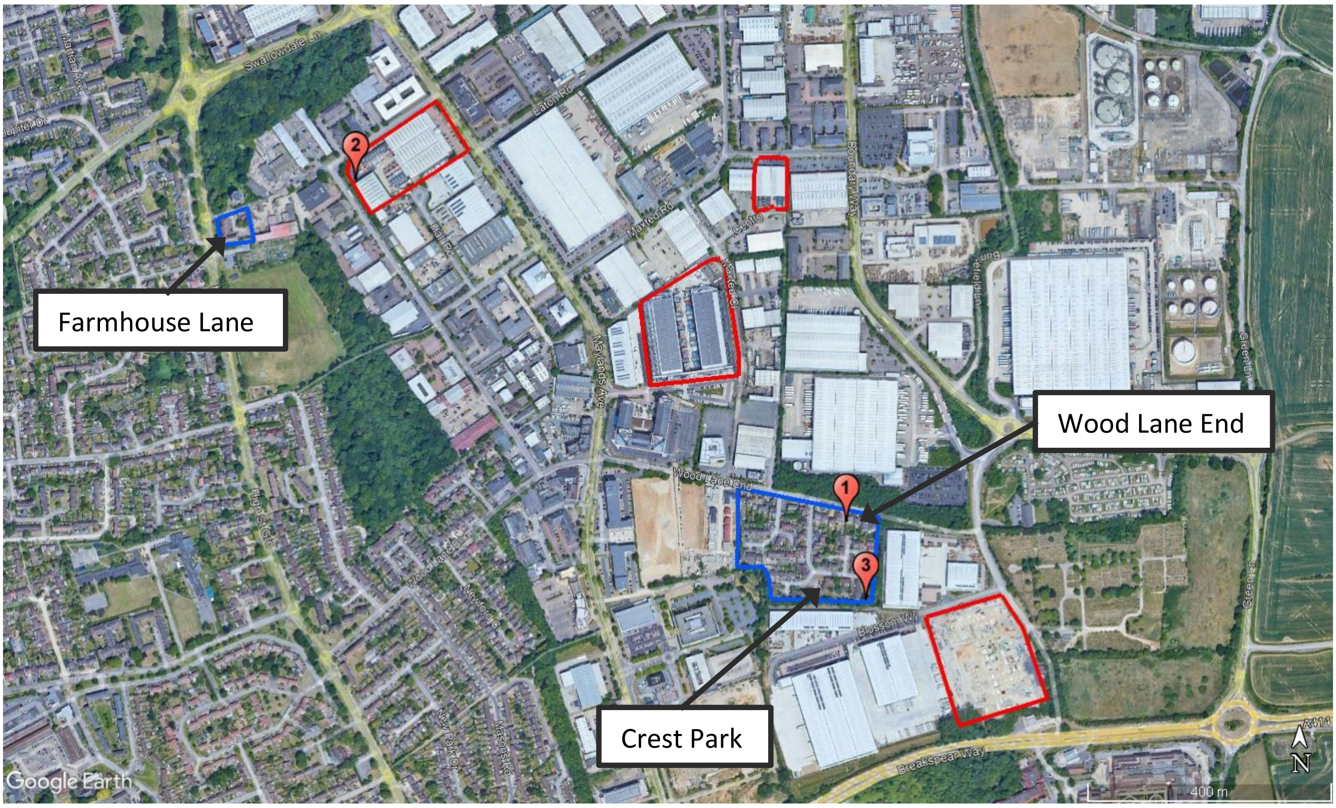
Table 4-1
Weather Conditions During Survey

Date	Period	Average Temperature (°C)	Average Wind Speed (ms^{-1})	Average Wind Direction	General Weather Conditions
Thursday 18th July 2019	Daytime	19	5.0	South Westerly	Clear and dry
	Night Time	13	2.8	West South Westerly	No rain
Friday 19th July 2019	Daytime	16	4.3	Southerly	Clear and dry
	Night Time	16	3.9	West South Westerly	No rain
Saturday 20th July 2019	Daytime	20	7.1	West South Westerly	Clear and dry
	Night Time	14	3.8	West South Westerly	No rain
Sunday 21st July 2019	Daytime	20	4.6	South Westerly	Clear and dry
	Night Time	16	4.9	South South Westerly	No rain
Monday 22nd July 2019	Daytime	24	4.9	South Westerly	Clear and dry
	Night Time	17	1.2	South Westerly	No rain
Tuesday 23rd July 2019	Daytime	27	4.2	South Easterly	Clear and dry

4.3 Survey Locations and Equipment

Noise monitoring was undertaken at three locations as shown in Figure 4-1.

Figure 4-1
Monitoring Locations (Numbered Pins), Receptor Locations (Blue), and Datacentre Locations (Red)



At each location, the meter was set to log noise levels every 15-minutes throughout the survey. The noise meter at Crest Park failed on the 19th July. The site survey engineer noted a similar soundscape and noise climate at Wood Lane End and Crest Park. As such, the noise data measured at Wood Lane End have been used in relation to the Crest Park receptors.

At the survey locations, the microphone was placed 1.5 m above the local ground level in free-field conditions, i.e. at least 3.5 m from the nearest vertical, reflecting surface. The following noise level indices were recorded:

- $L_{Aeq,T}$: The A-weighted equivalent continuous noise level over the measurement period.
- L_{A90}: The A-weighted noise level exceeded for 90% of the measurement period. This parameter is often used to describe background noise.
- L_{A10}: The A-weighted noise level exceeded for 10% of the measurement period. This parameter is often used to describe road traffic noise.
- L_{Amax}: The maximum A-weighted noise level during the measurement period.

4.4 Equipment

The noise survey equipment used during the survey is detailed in Table 4-2. All measurement instrumentation was calibrated before and after the measurements. No significant drift was observed. The calibration chain is traceable via the United Kingdom Accreditation Service to National Standards held at the National Physical Laboratory.

Table 4-2
Survey Equipment

Location	Coordinates (X, Y)	Equipment	Serial Number
Location 1 - Wood Lane End	508112, 207932	Cirrus CR:171B Type 1 Sound Level Meter	G300561
		Cirrus CR:515 Acoustic Calibrator	87922
Location 2 - Farmhouse Lane	507469, 208436	Cirrus CR:171B Type 1 Sound Level Meter	G061094
		Cirrus CR:515 Acoustic Calibrator	59336
Location 3 – Crest Park	508279, 207774	Cirrus CR:171B Type 1 Sound Level Meter	G068726
		Cirrus CR:515 Acoustic Calibrator	60605

4.5 Baseline Sound Level Results

A summary of the survey results at Location 1 is shown in Table 4-3. The full survey results are available in **Appendix 02**.

Table 4-3
Location 1 - Summary of Measured Sound Levels, free-field, dB

Date	Period	$L_{Aeq,T}$	Median L_{A90}	Median L_{A10}	L_{Amax}
18th July 2019	Daytime	61	59	62	75
	Night-Time	57	53	55	68
19th July 2019	Daytime	63	62	64	77
	Night-Time	63	60	61	76
20th July 2019	Daytime	62	60	62	75
	Night-Time	57	52	56	74
21st July 2019	Daytime	61	56	60	81
	Night-Time	59	54	59	68
22nd July 2019	Daytime	67	65	67	97
	Night-Time	62	57	61	71
23rd July 2019	Daytime	61	59	62	75

Based on a statistical analysis of the results of the measurements, the representative background sound levels have been determined to be:

- Daytime: 58 dB(A)
- Night-Time: 51 dB(A)

These background sound levels will be used in the BS4142:2014+A1:2019 assessment for the relevant Noise Sensitive Receptors.

A summary of the survey results at Location 2 is shown in Table 4-4. The full survey results are available in **Appendix 02**.

Table 4-4
Location 2 - Summary of Measured Sound Levels, free-field, dB

Date	Period	$L_{Aeq,T}$	Median L_{A90}	Median L_{A10}	L_{Amax}
18th July 2019	Daytime	44	40	46	66
	Night-Time	41	35	39	72
19th July 2019	Daytime	48	45	49	76
	Night-Time	44	40	44	67
20th July 2019	Daytime	44	40	44	67
	Night-Time	40	37	40	62
21st July 2019	Daytime	46	42	48	75
	Night-Time	43	39	44	71
22nd July 2019	Daytime	46	42	47	70
	Night-Time	43	35	38	69
23rd July 2019	Daytime	44	40	46	66

Based on a statistical analysis of the results of the measurements, the representative background sound levels have been determined to be:

- Daytime: 43 dB(A)
- Night-Time: 37 dB(A)

These background sound levels will be used in the BS4142:2014+A1:2019 assessment for the relevant Noise Sensitive Receptors.

4.6 Uncertainty

In accordance with BS4142:2014+A1:2019 assessment the uncertainty associated with measured baseline sound levels requires discussion. Baseline sound level measurement uncertainty was minimised using the following steps:

- Measurement locations were representative of the nearest noise-sensitive receptors to the site;
- Measurements were undertaken using a suitable logging period considered to provide representative background sound levels;
- The sound measurements included an extended period;

- Measurements were rounded to the nearest one decimal place before the final calculations; and
- Instrumentation was appropriate and in accordance with Section 5 of BS4142:2014+A1:2019.

5.0 Noise Model

5.1 Noise Model Assumptions

The sound predictions in this assessment have been undertaken using a proprietary software-based noise model, CadnaA, which implements the full range of UK noise-based calculation methods. The calculation algorithms set out in ISO 9613-2:1996 *Acoustics – Attenuation of sound during propagation outdoors – Part 2 General method of calculation* have been used and the model assumes:

- A ground absorption factor of 0.5.
- Contour Data to include OS terrain data.
- A reflection factor of 2.

The physical development on Site consists of:

- 31 no. SBGs at the Campus site;
- 4 no. SBGs at the Centro site;
- 14 no. SBGs at the Maylands site; and
- 28 no. SBGs at the HH4 site (15 in Phase1, 13 in Phase 2).

Noise data for the above plant are shown in Table 5-1. The data for the SBGs at the Campus, Centro, and Maylands sites are measured data from a site visit undertaken on 18th July 2019. Measurements were undertaken around each unit and the highest measured level has been used to determine the source level. However, the SBGs at the HH4 site are required to achieve maximum noise levels at 1 m from the container of the SBGs, as stipulated within the Applied Acoustic Design Report *'19033/008/dd NTT HH4 Data Centre – Acoustic Specification'* dated 21 August 2020. This report is provided in **Appendix 05** for ease of reference.

Table 5-1
Octave Band Sound Data – SBGs

Name	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 KHz	2 KHz	4 KHz	8 KHz	A
All HH4 SBGs										
KOHLER T2500*, L_p at 1 m	-	48.0	63.0	60.0	56.0	53.0	51.0	47.0	51.0	60.0
All Campus SBGs										
X185CMTU, L_w	92.4	77.7	84.1	78.1	81.1	78.1	73.5	63.8	56	82.4
All Centro and 6no. Maylands SBGs										
X1000MTU, L_w	98.8	98.1	99.1	109.8	94.6	87.3	81.4	80	80.2	101.9
6no. Maylands SBGs										
X2200MTU, L_w	91.8	89.9	90.2	84.4	82.9	78.1	70.2	65.9	57.6	83.8
* Noise data as stipulated within the Applied Acoustic Design Report										

For the purpose of this noise assessment, based on the separating distances to the nearest noise-sensitive receptors, each SBGs type has been modelled as a point source.

The coordinates of each item of plant are detailed in **Appendix 04**.

6.0 Specific Noise Levels

Based on the results of noise modelling, the calculated specific noise levels at each of the receptor levels are presented in Table 6-1.

Daytime sound levels have been predicted at 1.5 m above local ground level, which is the approximate height of a ground floor window. Night-time sound levels have been predicted at 4 m above local ground level, which is the approximate height of a first-floor window.

Based on the accuracy of the prediction methodology, i.e., ISO9613-2, the uncertainty of the CadnaA model accuracy, i.e. barrier corrections for buildings, etc., it is considered that the results of the assessment are as accurate as reasonably practicable and considered to be within +/-3 dB. It is also considered that the results of the assessment are as accurate as reasonably practicable with downwind propagation and 100% on-time for all the plant.

Table 6-1
Calculated Specific Noise Levels, free field dB

Location	Location Coordinates	Period	Calculated Specific Noise Level, $L_{Aeq,T}$
Wood Lane End	508112, 207931	Daytime	40
		Night-Time	40
Farmhouse Lane	507262, 208345	Daytime	36
		Night-Time	37
Crest Park	508302, 207773	Daytime	37
		Night-Time	37

It is noted that the calculated specific noise level values presented in Table 6-1 are significantly lower than those calculated during Phase 1. This is attributed to an initial allowance for the HH4 SBGs to each produce 88 dB L_w. The specification for the noise levels from these SBGs is now significantly lower (See **Appendix 05**), and as such, the Phase 2 calculated specific noise levels at Crest Park and Wood Lane End are significantly less influenced by the HH4 SBGs.

Noise contour plots of the predicted specific sound level during the daytime and night-time can be seen in Figure 6-1 and Figure 6-2, respectively.

Figure 6-1
Daytime $L_{Aeq,T}$ Specific Noise Level – dB(A)

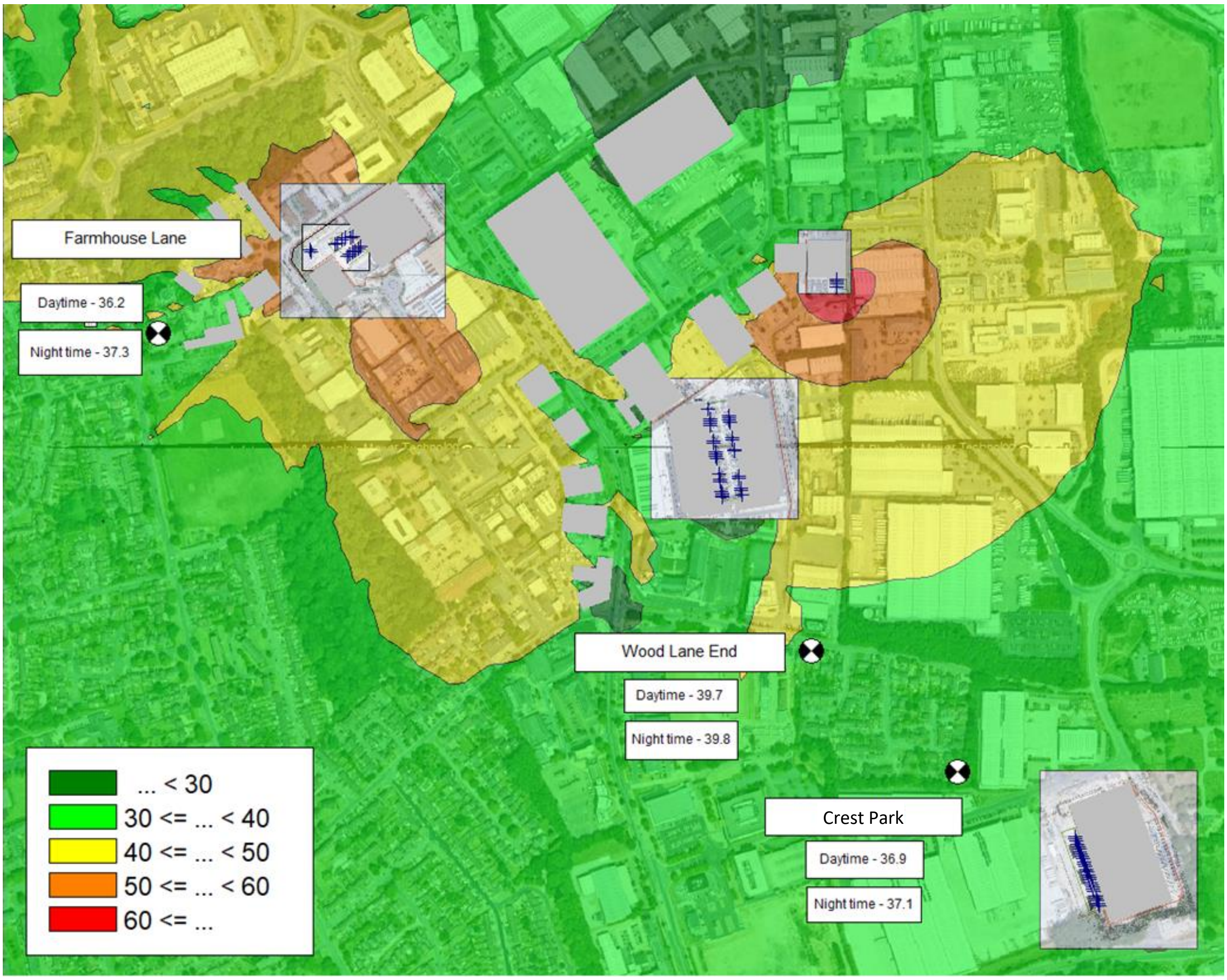
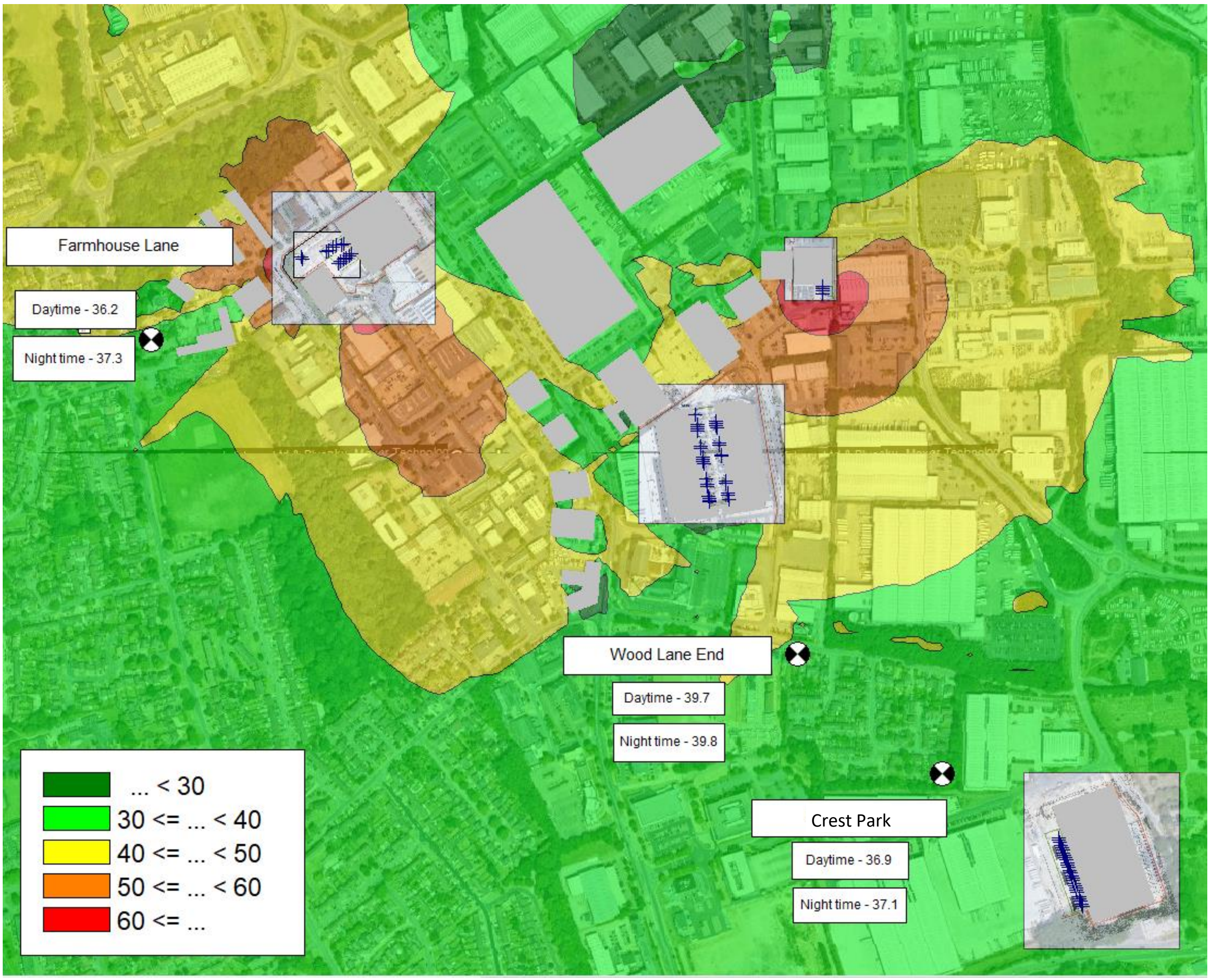


Figure 6-2
Night-Time $L_{Aeq,T}$ Specific Noise Level – dB(A)



7.0 BS4142:2014+A1:2019 Assessment

7.1 Representative Background Sound Levels

Analysis of the measured data has been undertaken to determine a representative background sound level for the assessment locations. It should be noted that the results from Maylands have been considered representative of Farmhouse Lane. The representative background sound levels at the assessment locations are presented in Table 7-1.

Table 7-1
Representative Background Sound Levels at the Assessment Locations, L_{A90} (dB)

Location	Daytime (07:00 – 23:00)	Night-time (23:00 – 07:00)
Wood Lane End	58	51
Farmhouse Lane	43	37
Crest Park	58	51

7.2 Sound Penalties

The character of each noise source and the sound penalty that will be applied in the BS4142:2014+A1:2019 assessment are detailed below:

- Tonality: SLR has not undertaken the BS4142:2014+A1:2019 *Objective method for assessing the audibility of tones in sound: one third octave method* on datasets for several operational SBGs. Given the noise climate in the area it is considered that tones may be just perceptible (+2 dB penalty).
- Impulsivity: With appropriate servicing of the SBGs they should not produce any impulsive sound. On this basis, no impulsivity penalties have been considered to apply.
- Other sound characteristics: No other sound characteristics are considered applicable.
- Intermittency: Over the BS4142:2014+A1:2019 reference period of 1-hour in the daytime (07:00 – 23:00) and 15-minutes at night-time (23:00 – 07:00), it is anticipated that the noise sources would be constant, therefore no intermittency penalty is required.

Based on the above, a 2 dB penalty is applicable to the predicted specific sound level at the nearest noise-sensitive receptors to derive the corresponding rating levels.

7.3 Assessment Results

The penalties described in Section 7.2 above have been added to the predicted sound levels shown in Table 6-1 to derive the rating levels at each of the nearest noise-sensitive receptors.

The rating levels have then been compared to the derived background sound levels, measured by SLR and assessed accordingly.

The results of the BS4142:2014+A1:2019 assessment are shown in Table 7-2. It must be noted that the rating levels and the representative background sound levels have been rounded to the nearest decibel.

Table 7-2
BS4142 Assessment, dB

Receptor	Assessment	Calculated Specific Noise Level, $L_{Aeq,T}$	Calculated Rating Level, $L_{Ar,T}$	Representative Background Sound Level L_{A90}	Difference
Wood Lane End	Daytime	40	42	58	-16
	Night-Time	40	42	51	-9
Farmhouse Lane	Daytime	36	38	43	-5
	Night-Time	37	39	37	+2
Crest Park	Daytime	37	39	48	-9
	Night-Time	37	39	43	-4

It can be seen from Table 7-1 that:

- During the daytime, the rating level of the SBGs would be between 5 dB(A) and 16 dB(A) below the background sound level. The specific sound level of the SBGs would increase the baseline ambient sound level[2] by less than 1 dB(A) at all identified receptors. These increases in the ambient noise level would not be perceptible. It is determined therefore the SBGs would be barely detectable during the daytime.
- During the night-time, the rating level of the SBGs would be between 9dB(A) below and 2 dB(A) above the background sound level. The specific sound level of the SBGs would increase the baseline ambient sound level[3] by less than 1 dB(A) at Wood Lane End and Crest Park, and by up to 3 dB at Farmhouse Lane. It is determined therefore that the SBGs would be barely detectable during the night-time.

It has therefore been concluded that the SBGs at the four data centres, including HH4 Phase 2, would result in a low impact and that action to minimise noise is a low priority.

[2] Lowest daytime $L_{Aeq,16\ hour}$ sound level taken from Table 4-3 and Table 4-4. 61 dB(A) at Location 1 and 44 dB(A) at Location 2.
[3] Lowest night-time $L_{Aeq,8\ hour}$ sound level taken from Table 4-3 and Table 4-4. 57 dB(A) at Location 1 and 40 dB(A) at Location 2.

8.0 Conclusion

NTT has appointed SLR to undertake an assessment to support an environmental permit variation application for Phase 2 of the HH4 data centre which will involve the installation and operation of an additional 13 SBGs at this data centre. For the purpose of this noise assessment, noise generated by the existing SBGs at the Maylands, Campus, Centro and HH4 (phase 1) data centres has also been taken into consideration.

The SBGs provide power to the site in the event that there is an emergency situation such as a brown- or black-out of the local electricity transmission network where there are fluctuations or loss of the electrical power provided by the network.

The noise assessment has been undertaken in accordance with British Standard 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound* and is based on the results of spot measurements of plant undertaken on site and a background sound survey conducted at nearby noise-sensitive receptors.

Operational sound levels associated with the proposed SBGs has been calculated at the closest receptors using the calculation methodologies in ISO 9613-2:1996 using the proprietary sound modelling software CadnaA®.

An assessment has been made with reference to British Standard 4142:2014+A1:2019.

It has been concluded that:

- During the daytime, the rating level of the SBGs would be between 5 dB(A) and 16 dB(A) below the background sound level. The specific sound level of the SBGs would increase the baseline ambient sound level[4] by less than 1 dB(A) at all identified receptors. These increases in the ambient noise level would not be perceptible. It is determined therefore the SBGs would be barely detectable during the daytime.
- During the night-time, the rating level of the SBGs would be between 9dB(A) below and 2 dB(A) above the background sound level. The specific sound level of the SBGs would increase the baseline ambient sound level[5] by less than 1 dB(A) at Wood Lane End and Crest Park, and by up to 3 dB at Farmhouse Lane. It is determined therefore the SBGs would be barely detectable during the night-time.

It is therefore concluded that the SBGs at the four data centres, including HH4 Phase 2, would result in a low impact and that action to minimise noise is a low priority.

[4] Lowest daytime $L_{Aeq,16\ hour}$ sound level taken from Table 4-3 and Table 4-4. 61 dB(A) at Location 1 and 44 dB(A) at Location 2.
[5] Lowest night-time $L_{Aeq,8\ hour}$ sound level taken from Table 4-3 and Table 4-4. 57 dB(A) at Location 1 and 40 dB(A) at Location 2.

APPENDIX 01

Glossary of Terminology

Glossary of Terminology

In order to assist the understanding of acoustic terminology and the relative change in noise, the following background information is provided.

The human ear can detect a very wide range of pressure fluctuations, which are perceived as sound. In order to express these fluctuations in a manageable way, a logarithmic scale called the decibel, or dB scale is used. The decibel scale typically ranges from 0 dB (the threshold of hearing) to over 120 dB. An indication of the range of sound levels commonly found in the environment is given in the following table.

Table 01-1
Sound Levels Commonly Found in the Environment

Sound Level	Location
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40 dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of Pain

Acoustic Terminology

dB (decibel) — The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2x10^{-5}$Pa).

dB(A) — A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

L_{Aeq} — L_{Aeq} is defined as the notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.

L_{10} & L_{90} — If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for *n*% of the time. Hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the 'average minimum level' and is often used to describe the background noise. It is common practice to use the L_{10} index to describe traffic noise.

L_{Amax} — L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.

APPENDIX 02

Survey Results

Table 02-1
Measured Noise Levels at Location 1, free-field, dB

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
18/07/2019	14:30	61.3	59.5	62.5	67.6
18/07/2019	14:45	60.1	59.6	60.5	66.1
18/07/2019	15:00	59.6	59.2	59.9	63.7
18/07/2019	15:15	59.9	59.4	60.2	62.0
18/07/2019	15:30	63.2	60.3	65.9	68.1
18/07/2019	15:45	63.5	61.9	66.6	68.8
18/07/2019	16:00	60.0	58.3	60.8	63.5
18/07/2019	16:15	59.5	58.4	60.7	65.1
18/07/2019	16:30	64.4	62.1	65.7	67.1
18/07/2019	16:45	61.8	61.0	62.4	65.0
18/07/2019	17:00	64.2	61.1	66.8	68.7
18/07/2019	17:15	60.5	58.2	61.6	65.1
18/07/2019	17:30	54.7	53.3	55.6	58.9
18/07/2019	17:45	62.2	56.7	65.5	67.1
18/07/2019	18:00	62.7	61.0	64.7	66.6
18/07/2019	18:15	63.0	61.1	65.2	67.9
18/07/2019	18:30	63.3	60.5	66.9	69.1
18/07/2019	18:45	58.7	57.2	60.4	64.4
18/07/2019	19:00	64.1	61.7	65.8	68.1
18/07/2019	19:15	60.0	58.2	61.6	63.4
18/07/2019	19:30	58.2	55.7	58.8	63.8
18/07/2019	19:45	59.1	55.9	61.2	64.1
18/07/2019	20:00	64.9	61.9	67.1	69.1
18/07/2019	20:15	64.2	60.2	66.4	75.2
18/07/2019	20:30	58.6	57.8	59.7	62.7
18/07/2019	20:45	56.0	52.7	58.3	62.2
18/07/2019	21:00	54.5	52.8	55.7	63.0
18/07/2019	21:15	61.7	56.4	64.9	67.0
18/07/2019	21:30	62.8	60.4	65.6	67.0
18/07/2019	21:45	61.3	60.3	62.1	66.2
18/07/2019	22:00	58.3	53.4	61.7	66.4
18/07/2019	22:15	54.9	53.2	56.1	60.7
18/07/2019	22:30	57.5	55.9	58.8	74.1
18/07/2019	22:45	62.6	59.6	64.7	66.3
18/07/2019	23:00	62.3	58.9	65.3	66.9
18/07/2019	23:15	58.0	54.8	59.1	65.1

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
18/07/2019	23:30	53.4	51.6	54.5	61.1
18/07/2019	23:45	52.9	51.4	53.9	56.1
19/07/2019	00:00	54.4	52.3	55.3	61.6
19/07/2019	00:15	58.2	55.5	59.4	65.5
19/07/2019	00:30	61.8	60.1	63.1	64.9
19/07/2019	00:45	64.5	63.7	65.2	66.7
19/07/2019	01:00	63.2	58.9	65.3	66.6
19/07/2019	01:15	58.1	54.5	59.1	60.8
19/07/2019	01:30	52.5	51.0	53.3	58.7
19/07/2019	01:45	52.6	50.7	54.3	55.9
19/07/2019	02:00	53.2	51.2	54.5	55.8
19/07/2019	02:15	54.3	53.4	55.3	56.5
19/07/2019	02:30	54.3	53.2	55.3	57.1
19/07/2019	02:45	54.9	53.9	55.8	60.7
19/07/2019	03:00	55.8	54.9	56.3	61.4
19/07/2019	03:15	56.7	54.2	56.8	67.8
19/07/2019	03:30	55.1	54.2	55.9	57.3
19/07/2019	03:45	54.9	53.8	55.9	58.3
19/07/2019	04:00	54.7	54.0	55.2	63.2
19/07/2019	04:15	53.5	52.4	54.4	58.5
19/07/2019	04:30	53.3	52.0	54.1	61.1
19/07/2019	04:45	53.1	52.1	53.8	56.6
19/07/2019	05:00	53.2	52.6	53.7	58.5
19/07/2019	05:15	52.3	51.0	53.1	58.3
19/07/2019	05:30	52.1	50.7	53.0	59.5
19/07/2019	05:45	52.8	51.2	53.7	61.0
19/07/2019	06:00	53.0	51.8	53.8	67.8
19/07/2019	06:15	53.1	51.3	54.5	65.7
19/07/2019	06:30	53.2	51.2	54.6	60.8
19/07/2019	06:45	54.1	52.2	55.5	59.4
19/07/2019	07:00	53.3	51.8	54.3	65.7
19/07/2019	07:15	53.7	52.4	54.6	61.0
19/07/2019	07:30	55.2	54.0	56.0	74.9
19/07/2019	07:45	56.7	55.3	57.4	76.5
19/07/2019	08:00	57.8	57.0	58.6	61.8
19/07/2019	08:15	59.6	58.5	60.7	63.7
19/07/2019	08:30	61.9	60.9	62.9	65.0
19/07/2019	08:45	63.7	62.5	64.8	70.0

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
19/07/2019	09:00	61.5	58.6	65.2	68.0
19/07/2019	09:15	58.1	53.4	59.5	64.7
19/07/2019	09:30	54.7	52.5	55.4	65.9
19/07/2019	09:45	54.7	52.7	55.6	60.3
19/07/2019	10:00	59.7	56.1	61.3	64.0
19/07/2019	10:15	63.9	61.9	65.6	67.7
19/07/2019	10:30	60.7	59.1	61.8	64.1
19/07/2019	10:45	58.8	58.3	59.2	66.4
19/07/2019	11:00	56.0	54.2	57.2	65.8
19/07/2019	11:15	57.2	55.2	58.4	69.8
19/07/2019	11:30	56.0	53.4	57.4	70.0
19/07/2019	11:45	54.5	53.8	55.1	64.3
19/07/2019	12:00	58.6	55.8	59.7	65.4
19/07/2019	12:15	61.7	60.2	63.1	64.9
19/07/2019	12:30	64.6	62.6	65.8	67.9
19/07/2019	12:45	61.3	59.9	62.7	63.8
19/07/2019	13:00	59.7	58.4	62.5	64.0
19/07/2019	13:15	59.1	58.3	59.9	62.6
19/07/2019	13:30	57.2	56.4	57.9	65.3
19/07/2019	13:45	57.3	55.1	59.0	60.7
19/07/2019	14:00	63.3	60.0	65.5	67.2
19/07/2019	14:15	64.5	63.3	65.8	72.5
19/07/2019	14:30	63.2	62.5	63.8	65.2
19/07/2019	14:45	61.8	60.7	62.7	65.1
19/07/2019	15:00	60.7	60.1	61.1	75.5
19/07/2019	15:15	60.6	60.0	61.0	64.7
19/07/2019	15:30	60.8	60.1	61.6	63.4
19/07/2019	15:45	61.8	61.3	62.2	63.7
19/07/2019	16:00	62.0	61.4	62.6	64.8
19/07/2019	16:15	62.3	61.6	62.9	66.2
19/07/2019	16:30	62.6	61.9	63.3	64.7
19/07/2019	16:45	63.7	62.6	64.5	66.3
19/07/2019	17:00	64.5	63.7	65.1	66.4
19/07/2019	17:15	64.6	63.8	65.2	66.6
19/07/2019	17:30	64.9	64.3	65.5	66.9
19/07/2019	17:45	65.1	64.5	65.6	67.4
19/07/2019	18:00	65.7	65.0	66.2	67.7
19/07/2019	18:15	65.9	65.4	66.3	67.5

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
19/07/2019	18:30	65.8	65.3	66.2	68.0
19/07/2019	18:45	65.8	65.3	66.2	67.2
19/07/2019	19:00	65.8	65.3	66.1	67.4
19/07/2019	19:15	66.1	65.6	66.5	67.7
19/07/2019	19:30	66.1	65.6	66.5	69.4
19/07/2019	19:45	65.8	65.3	66.2	68.1
19/07/2019	20:00	65.8	65.3	66.2	69.5
19/07/2019	20:15	65.9	65.3	66.3	67.5
19/07/2019	20:30	66.2	65.6	66.6	67.6
19/07/2019	20:45	66.1	65.6	66.5	67.7
19/07/2019	21:00	65.8	65.3	66.2	67.5
19/07/2019	21:15	65.8	65.3	66.2	67.4
19/07/2019	21:30	65.9	65.4	66.3	67.3
19/07/2019	21:45	66.2	65.7	66.6	67.7
19/07/2019	22:00	66.0	65.4	66.4	67.5
19/07/2019	22:15	65.8	65.3	66.2	67.2
19/07/2019	22:30	65.8	65.3	66.2	67.2
19/07/2019	22:45	66.1	65.5	66.5	67.8
19/07/2019	23:00	66.0	65.5	66.4	67.5
19/07/2019	23:15	65.8	65.3	66.3	67.4
19/07/2019	23:30	65.8	65.3	66.2	67.5
19/07/2019	23:45	65.8	65.3	66.2	67.3
20/07/2019	00:00	65.9	65.5	66.3	67.3
20/07/2019	00:15	65.3	64.7	65.8	67.0
20/07/2019	00:30	65.0	64.5	65.4	66.4
20/07/2019	00:45	64.9	64.4	65.3	66.7
20/07/2019	01:00	65.1	64.5	65.5	66.6
20/07/2019	01:15	65.1	64.5	65.5	66.6
20/07/2019	01:30	64.6	64.0	65.0	66.3
20/07/2019	01:45	64.4	63.8	64.8	67.3
20/07/2019	02:00	63.9	63.1	64.5	67.7
20/07/2019	02:15	63.1	62.4	63.7	67.7
20/07/2019	02:30	61.5	60.5	62.4	66.0
20/07/2019	02:45	60.2	59.7	60.6	64.0
20/07/2019	03:00	59.3	58.8	59.8	61.0
20/07/2019	03:15	59.2	58.5	59.7	60.6
20/07/2019	03:30	60.0	59.2	60.6	61.5
20/07/2019	03:45	58.9	58.3	59.5	61.5

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	04:00	58.8	58.2	59.3	63.4
20/07/2019	04:15	58.7	58.2	59.0	61.8
20/07/2019	04:30	59.7	59.0	60.3	61.2
20/07/2019	04:45	59.4	58.6	60.3	64.7
20/07/2019	05:00	58.8	58.2	59.1	76.0
20/07/2019	05:15	58.8	58.3	59.3	60.9
20/07/2019	05:30	59.1	58.3	59.7	65.9
20/07/2019	05:45	60.0	59.4	60.4	61.3
20/07/2019	06:00	58.9	58.4	59.3	61.1
20/07/2019	06:15	58.7	58.2	59.1	61.0
20/07/2019	06:30	58.8	58.2	59.4	61.3
20/07/2019	06:45	59.8	58.5	60.4	62.8
20/07/2019	07:00	59.5	58.4	60.2	62.3
20/07/2019	07:15	58.7	58.2	59.2	61.6
20/07/2019	07:30	58.8	58.2	59.4	63.1
20/07/2019	07:45	58.9	58.4	59.3	64.9
20/07/2019	08:00	60.3	59.9	60.6	63.2
20/07/2019	08:15	59.5	58.8	60.2	61.6
20/07/2019	08:30	59.4	58.9	59.7	67.7
20/07/2019	08:45	60.0	59.6	60.4	61.9
20/07/2019	09:00	61.0	59.9	62.0	63.3
20/07/2019	09:15	62.3	61.8	62.8	65.6
20/07/2019	09:30	62.4	61.7	63.0	66.0
20/07/2019	09:45	63.9	62.5	65.0	66.7
20/07/2019	10:00	66.9	64.1	68.9	70.8
20/07/2019	10:15	66.1	64.4	66.8	68.6
20/07/2019	10:30	66.1	65.6	66.5	68.3
20/07/2019	10:45	65.8	65.2	66.2	69.4
20/07/2019	11:00	65.3	64.7	65.8	68.6
20/07/2019	11:15	65.4	64.8	65.9	67.7
20/07/2019	11:30	65.7	65.1	66.2	72.2
20/07/2019	11:45	65.1	64.3	65.7	67.8
20/07/2019	12:00	64.2	63.4	64.8	66.2
20/07/2019	12:15	64.9	64.3	65.4	66.7
20/07/2019	12:30	64.8	63.7	65.6	67.5
20/07/2019	12:45	66.6	63.9	68.5	70.3
20/07/2019	13:00	63.7	61.6	64.8	66.3
20/07/2019	13:15	60.8	59.9	61.5	70.0

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	13:30	59.8	59.2	60.2	73.7
20/07/2019	13:45	59.1	58.5	59.5	63.3
20/07/2019	14:00	63.2	60.0	65.8	68.6
20/07/2019	14:15	63.6	60.9	67.0	74.8
20/07/2019	14:30	59.7	58.3	61.4	64.0
20/07/2019	14:45	58.7	58.2	59.1	63.3
20/07/2019	15:00	58.5	58.1	58.8	60.4
20/07/2019	15:15	61.5	59.0	64.0	67.0
20/07/2019	15:30	64.3	61.5	67.1	68.9
20/07/2019	15:45	61.3	59.8	62.5	64.5
20/07/2019	16:00	60.0	59.5	60.3	64.0
20/07/2019	16:15	60.0	59.5	60.3	63.8
20/07/2019	16:30	60.5	59.6	61.4	64.0
20/07/2019	16:45	64.7	61.7	67.1	69.2
20/07/2019	17:00	61.9	59.6	62.8	64.4
20/07/2019	17:15	58.5	57.9	59.5	60.8
20/07/2019	17:30	58.0	57.5	58.2	62.4
20/07/2019	17:45	57.9	57.5	58.2	60.9
20/07/2019	18:00	59.3	58.0	60.7	62.7
20/07/2019	18:15	64.7	61.6	67.0	68.8
20/07/2019	18:30	62.0	60.2	63.3	67.1
20/07/2019	18:45	58.1	57.6	58.3	68.3
20/07/2019	19:00	58.1	57.7	58.3	63.9
20/07/2019	19:15	58.5	57.9	59.0	61.9
20/07/2019	19:30	59.9	59.5	60.1	62.4
20/07/2019	19:45	60.9	59.6	62.3	66.7
20/07/2019	20:00	64.8	61.9	66.7	68.8
20/07/2019	20:15	60.2	57.8	61.8	63.1
20/07/2019	20:30	59.0	58.0	59.8	61.5
20/07/2019	20:45	58.5	54.1	59.7	64.7
20/07/2019	21:00	55.5	53.8	56.7	61.9
20/07/2019	21:15	61.2	57.8	63.6	65.6
20/07/2019	21:30	63.9	61.3	65.5	67.3
20/07/2019	21:45	60.7	59.4	61.4	63.4
20/07/2019	22:00	58.4	57.9	58.9	62.0
20/07/2019	22:15	54.7	51.9	58.3	61.2
20/07/2019	22:30	55.7	53.8	57.8	59.2
20/07/2019	22:45	60.8	58.7	62.3	64.1

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	23:00	64.2	62.2	65.5	66.8
20/07/2019	23:15	59.6	58.2	60.8	63.4
20/07/2019	23:30	57.6	54.2	58.5	62.3
20/07/2019	23:45	54.3	52.1	56.4	57.9
21/07/2019	00:00	54.9	53.9	55.7	57.2
21/07/2019	00:15	56.5	54.9	57.7	63.2
21/07/2019	00:30	58.8	57.3	59.5	73.6
21/07/2019	00:45	59.9	58.9	60.7	62.5
21/07/2019	01:00	62.0	60.3	63.7	65.4
21/07/2019	01:15	57.3	50.5	61.8	68.1
21/07/2019	01:30	52.1	50.3	53.6	55.6
21/07/2019	01:45	53.2	50.9	55.3	68.5
21/07/2019	02:00	53.0	51.7	53.7	68.9
21/07/2019	02:15	53.1	51.0	55.1	57.0
21/07/2019	02:30	53.2	52.2	54.0	55.0
21/07/2019	02:45	55.2	53.4	55.9	57.0
21/07/2019	03:00	57.2	56.0	58.0	59.3
21/07/2019	03:15	57.8	56.3	58.7	60.1
21/07/2019	03:30	54.2	51.4	56.1	69.0
21/07/2019	03:45	52.7	51.0	53.7	54.9
21/07/2019	04:00	52.1	49.8	53.6	68.9
21/07/2019	04:15	52.6	51.0	53.7	70.1
21/07/2019	04:30	53.4	51.4	54.4	70.1
21/07/2019	04:45	53.4	52.3	54.4	58.1
21/07/2019	05:00	53.9	52.4	54.7	67.8
21/07/2019	05:15	55.5	54.0	56.2	61.4
21/07/2019	05:30	55.8	53.3	56.6	74.4
21/07/2019	05:45	52.2	49.2	53.9	60.0
21/07/2019	06:00	51.3	49.2	52.7	56.0
21/07/2019	06:15	52.8	49.8	54.5	61.3
21/07/2019	06:30	54.0	52.9	54.7	70.2
21/07/2019	06:45	53.7	51.7	55.2	59.8
21/07/2019	07:00	56.2	54.3	57.7	61.0
21/07/2019	07:15	60.6	57.8	62.6	64.8
21/07/2019	07:30	64.3	59.7	65.7	67.6
21/07/2019	07:45	59.1	58.0	60.3	64.7
21/07/2019	08:00	52.9	50.2	54.3	68.4
21/07/2019	08:15	53.1	51.1	54.9	58.6

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
21/07/2019	08:30	56.3	55.1	56.9	68.6
21/07/2019	08:45	57.1	54.7	58.5	68.4
21/07/2019	09:00	61.2	58.3	63.3	67.8
21/07/2019	09:15	66.6	63.4	68.8	70.5
21/07/2019	09:30	61.6	59.4	63.2	66.0
21/07/2019	09:45	55.3	51.1	59.1	68.1
21/07/2019	10:00	51.9	50.7	52.7	66.0
21/07/2019	10:15	53.2	51.9	54.0	64.9
21/07/2019	10:30	57.0	53.4	59.0	64.7
21/07/2019	10:45	63.7	59.7	66.6	74.6
21/07/2019	11:00	65.6	61.9	68.2	69.8
21/07/2019	11:15	60.5	57.9	62.3	63.8
21/07/2019	11:30	52.3	50.8	53.0	68.9
21/07/2019	11:45	52.2	50.5	53.3	59.3
21/07/2019	12:00	55.3	52.7	56.9	58.2
21/07/2019	12:15	61.4	57.3	64.2	76.4
21/07/2019	12:30	66.4	62.6	68.8	70.5
21/07/2019	12:45	62.1	59.7	63.1	64.0
21/07/2019	13:00	57.8	55.8	62.0	69.3
21/07/2019	13:15	56.7	55.5	57.6	63.8
21/07/2019	13:30	57.4	56.7	58.0	68.1
21/07/2019	13:45	64.3	58.2	68.0	70.6
21/07/2019	14:00	64.3	61.3	68.0	70.2
21/07/2019	14:15	59.3	57.8	61.5	62.4
21/07/2019	14:30	53.4	52.0	54.2	70.0
21/07/2019	14:45	53.6	52.3	54.5	60.0
21/07/2019	15:00	58.7	54.5	61.2	63.5
21/07/2019	15:15	66.3	62.4	69.0	70.8
21/07/2019	15:30	63.3	61.9	64.1	65.8
21/07/2019	15:45	59.8	57.0	61.0	63.9
21/07/2019	16:00	56.5	55.7	57.0	69.2
21/07/2019	16:15	57.0	56.2	57.7	64.1
21/07/2019	16:30	60.2	57.7	62.2	65.0
21/07/2019	16:45	66.2	62.8	68.6	70.7
21/07/2019	17:00	62.5	60.1	63.5	65.2
21/07/2019	17:15	58.1	53.4	59.5	62.6
21/07/2019	17:30	53.5	51.7	54.6	69.0
21/07/2019	17:45	58.4	52.9	56.6	80.6

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
21/07/2019	18:00	61.9	58.2	64.7	67.9
21/07/2019	18:15	66.4	63.0	69.1	70.7
21/07/2019	18:30	62.5	60.1	63.8	65.3
21/07/2019	18:45	58.3	56.5	59.9	69.4
21/07/2019	19:00	56.6	55.9	56.9	63.6
21/07/2019	19:15	57.5	56.3	58.1	62.2
21/07/2019	19:30	59.9	57.9	61.9	64.7
21/07/2019	19:45	66.2	63.3	68.1	70.3
21/07/2019	20:00	62.3	59.4	63.7	72.6
21/07/2019	20:15	56.5	52.1	58.7	67.4
21/07/2019	20:30	52.7	51.2	53.5	61.3
21/07/2019	20:45	53.8	52.4	54.6	68.5
21/07/2019	21:00	56.4	54.9	57.2	63.2
21/07/2019	21:15	60.4	57.3	62.8	65.3
21/07/2019	21:30	66.6	63.5	68.4	70.1
21/07/2019	21:45	61.8	58.6	63.5	66.4
21/07/2019	22:00	56.1	53.8	57.8	68.6
21/07/2019	22:15	54.5	52.3	56.3	61.0
21/07/2019	22:30	52.9	51.0	54.1	68.7
21/07/2019	22:45	53.8	52.2	54.9	61.9
21/07/2019	23:00	55.4	53.5	57.3	58.9
21/07/2019	23:15	60.1	58.4	61.6	65.5
21/07/2019	23:30	63.8	60.7	65.6	66.9
21/07/2019	23:45	59.2	58.4	60.1	63.2
22/07/2019	00:00	54.6	51.4	58.5	67.8
22/07/2019	00:15	53.8	52.3	54.9	56.1
22/07/2019	00:30	51.8	50.0	53.2	54.9
22/07/2019	00:45	52.7	51.3	54.2	58.9
22/07/2019	01:00	53.4	52.3	54.5	55.9
22/07/2019	01:15	56.7	55.8	57.3	58.6
22/07/2019	01:30	59.9	57.8	61.7	64.3
22/07/2019	01:45	64.1	61.9	65.6	67.1
22/07/2019	02:00	60.1	58.8	61.2	63.0
22/07/2019	02:15	57.2	55.2	59.0	68.0
22/07/2019	02:30	52.9	51.6	54.2	56.0
22/07/2019	02:45	52.1	50.1	54.0	55.9
22/07/2019	03:00	52.8	51.1	53.8	55.4
22/07/2019	03:15	56.4	53.6	58.6	59.9

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
22/07/2019	03:30	60.5	59.1	61.7	63.2
22/07/2019	03:45	64.1	62.0	65.6	66.8
22/07/2019	04:00	61.5	60.4	62.7	66.0
22/07/2019	04:15	57.9	53.9	59.6	67.8
22/07/2019	04:30	55.9	54.2	57.2	60.9
22/07/2019	04:45	53.5	52.0	54.8	62.4
22/07/2019	05:00	52.7	52.0	53.3	60.2
22/07/2019	05:15	56.0	54.0	57.5	59.1
22/07/2019	05:30	60.3	58.5	61.8	63.8
22/07/2019	05:45	64.4	62.6	65.8	67.1
22/07/2019	06:00	61.6	60.2	62.4	64.7
22/07/2019	06:15	58.3	52.7	59.9	62.0
22/07/2019	06:30	53.4	51.7	54.8	68.3
22/07/2019	06:45	56.3	54.0	57.5	60.1
22/07/2019	07:00	58.3	57.0	59.8	64.9
22/07/2019	07:15	61.8	59.8	63.2	64.9
22/07/2019	07:30	64.6	62.8	66.0	76.5
22/07/2019	07:45	63.7	62.9	64.3	65.8
22/07/2019	08:00	62.8	61.4	63.9	65.4
22/07/2019	08:15	59.9	59.0	61.0	62.7
22/07/2019	08:30	57.1	55.5	58.8	68.6
22/07/2019	08:45	61.0	58.4	63.1	65.7
22/07/2019	09:00	66.1	63.5	67.5	73.7
22/07/2019	09:15	66.3	65.3	66.9	68.1
22/07/2019	09:30	65.8	65.3	66.2	70.8
22/07/2019	09:45	63.7	61.6	65.4	66.9
22/07/2019	10:00	75.4	61.2	79.7	93.4
22/07/2019	10:15	70.0	62.9	68.9	86.4
22/07/2019	10:30	65.2	62.8	66.5	67.8
22/07/2019	10:45	65.6	64.9	66.3	67.4
22/07/2019	11:00	65.4	64.9	65.9	67.4
22/07/2019	11:15	65.8	65.0	66.4	67.6
22/07/2019	11:30	67.5	65.2	69.1	70.8
22/07/2019	11:45	66.5	64.3	67.6	69.1
22/07/2019	12:00	77.1	65.9	76.7	96.5
22/07/2019	12:15	65.8	65.2	66.2	67.7
22/07/2019	12:30	65.9	65.1	66.6	67.8
22/07/2019	12:45	67.4	65.0	68.9	70.9

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
22/07/2019	13:00	66.4	64.3	67.5	69.1
22/07/2019	13:15	66.1	65.2	66.7	68.5
22/07/2019	13:30	65.7	65.1	66.1	67.2
22/07/2019	13:45	66.5	64.9	68.1	70.4
22/07/2019	14:00	67.2	64.7	68.8	70.7
22/07/2019	14:15	66.3	64.5	67.3	68.9
22/07/2019	14:30	65.8	65.1	66.5	67.8
22/07/2019	14:45	65.7	65.0	66.2	67.4
22/07/2019	15:00	67.2	65.0	69.0	70.7
22/07/2019	15:15	66.4	64.0	67.6	69.3
22/07/2019	15:30	66.2	64.4	67.3	69.3
22/07/2019	15:45	65.9	65.2	66.5	67.7
22/07/2019	16:00	65.8	65.1	66.4	67.6
22/07/2019	16:15	67.3	65.0	68.9	70.6
22/07/2019	16:30	66.5	64.0	67.8	69.1
22/07/2019	16:45	66.2	64.5	67.2	68.8
22/07/2019	17:00	65.9	65.2	66.5	67.7
22/07/2019	17:15	65.7	65.0	66.2	67.6
22/07/2019	17:30	67.3	64.9	69.0	70.9
22/07/2019	17:45	66.5	64.0	67.7	69.2
22/07/2019	18:00	66.1	64.5	67.0	69.1
22/07/2019	18:15	65.8	65.2	66.4	69.8
22/07/2019	18:30	65.8	65.1	66.2	68.4
22/07/2019	18:45	67.3	65.1	69.0	70.6
22/07/2019	19:00	66.6	64.2	67.9	69.4
22/07/2019	19:15	66.3	64.8	67.1	68.4
22/07/2019	19:30	65.8	65.2	66.3	67.7
22/07/2019	19:45	65.5	65.0	65.9	67.5
22/07/2019	20:00	66.7	64.9	68.5	70.4
22/07/2019	20:15	67.0	64.6	68.7	70.4
22/07/2019	20:30	66.4	65.0	67.1	68.6
22/07/2019	20:45	65.8	65.3	66.1	67.0
22/07/2019	21:00	65.8	65.3	66.1	69.2
22/07/2019	21:15	66.0	65.2	66.5	67.8
22/07/2019	21:30	67.5	65.3	69.0	70.7
22/07/2019	21:45	66.2	64.4	67.2	68.9
22/07/2019	22:00	65.8	65.0	66.4	67.5
22/07/2019	22:15	65.8	65.2	66.2	67.4

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
22/07/2019	22:30	65.7	65.0	66.1	67.9
22/07/2019	22:45	64.6	64.1	65.1	66.2
22/07/2019	23:00	65.8	64.0	67.2	69.1
22/07/2019	23:15	67.7	65.3	69.2	70.7
22/07/2019	23:30	66.3	65.0	67.1	68.4
22/07/2019	23:45	60.8	58.2	63.8	66.1
23/07/2019	00:00	53.0	52.0	53.5	68.7
23/07/2019	00:15	54.1	52.7	55.2	56.9
23/07/2019	00:30	59.0	55.9	60.6	62.2
23/07/2019	00:45	63.5	61.0	65.6	68.1
23/07/2019	01:00	67.0	64.2	68.6	70.7
23/07/2019	01:15	64.2	62.0	65.4	67.4
23/07/2019	01:30	58.5	52.8	60.4	63.3
23/07/2019	01:45	55.7	52.0	57.4	68.1
23/07/2019	02:00	57.3	56.7	58.0	59.6
23/07/2019	02:15	55.5	54.6	56.3	57.7
23/07/2019	02:30	58.8	56.4	60.7	62.5
23/07/2019	02:45	64.0	61.3	66.1	68.3
23/07/2019	03:00	64.7	63.1	66.4	67.9
23/07/2019	03:15	62.0	59.5	63.5	65.1
23/07/2019	03:30	55.5	51.5	58.8	67.7
23/07/2019	03:45	52.2	50.5	53.6	55.2
23/07/2019	04:00	53.4	51.5	54.8	56.0
23/07/2019	04:15	57.3	56.1	57.8	59.9
23/07/2019	04:30	58.5	57.3	59.9	61.9
23/07/2019	04:45	61.6	60.4	62.6	68.5
23/07/2019	05:00	64.7	63.3	65.7	66.8
23/07/2019	05:15	62.7	61.4	63.7	65.4
23/07/2019	05:30	58.5	54.7	60.5	68.1
23/07/2019	05:45	53.3	51.8	54.8	60.0
23/07/2019	06:00	54.1	52.7	55.3	63.7
23/07/2019	06:15	55.1	53.6	56.4	62.4
23/07/2019	06:30	60.9	57.6	62.9	65.0
23/07/2019	06:45	66.4	63.2	68.5	70.6
23/07/2019	07:00	65.1	63.2	66.7	69.2
23/07/2019	07:15	61.3	58.6	63.6	66.1
23/07/2019	07:30	56.0	53.1	58.8	68.7
23/07/2019	07:45	57.9	57.1	58.5	67.8

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
23/07/2019	08:00	59.7	58.3	61.0	62.6
23/07/2019	08:15	65.7	61.7	68.3	76.8
23/07/2019	08:30	66.0	63.7	67.4	69.8
23/07/2019	08:45	66.2	65.5	66.8	69.0
23/07/2019	09:00	65.8	65.3	66.2	67.3
23/07/2019	09:15	65.7	65.1	66.2	67.6
23/07/2019	09:30	67.4	65.1	69.2	70.9
23/07/2019	09:45	66.8	64.6	68.0	69.6
23/07/2019	10:00	66.6	65.6	67.2	68.5
23/07/2019	10:15	65.9	65.4	66.3	67.8
23/07/2019	10:30	65.9	65.2	66.4	72.6

Table 02-2
Measured Noise Levels at Location 2, free-field, dB

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
18/07/2019	13:45	45.0	41.6	46.7	65.0
18/07/2019	14:00	44.5	40.0	45.9	62.3
18/07/2019	14:15	44.5	40.6	46.5	58.7
18/07/2019	14:30	46.6	42.0	49.1	65.8
18/07/2019	14:45	44.6	40.9	46.5	61.4
18/07/2019	15:00	44.4	41.3	46.2	62.1
18/07/2019	15:15	44.3	41.2	46.3	57.9
18/07/2019	15:30	44.6	40.6	46.9	57.4
18/07/2019	15:45	44.6	40.8	45.5	64.2
18/07/2019	16:00	45.1	41.8	46.9	60.0
18/07/2019	16:15	45.9	42.1	47.4	65.6
18/07/2019	16:30	45.5	42.1	47.5	57.8
18/07/2019	16:45	45.3	42.4	46.9	60.2
18/07/2019	17:00	44.5	42.5	45.9	53.8
18/07/2019	17:15	45.6	41.4	46.9	63.1
18/07/2019	17:30	43.3	40.3	44.9	55.0
18/07/2019	17:45	43.5	40.3	44.6	58.0
18/07/2019	18:00	42.9	39.0	45.1	58.6
18/07/2019	18:15	44.5	41.6	46.4	56.8
18/07/2019	18:30	43.9	41.4	45.6	55.8

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
18/07/2019	18:45	44.8	40.4	44.3	65.4
18/07/2019	19:00	43.9	40.7	45.9	59.8
18/07/2019	19:15	42.8	39.6	44.6	59.4
18/07/2019	19:30	42.3	39.1	44.3	56.2
18/07/2019	19:45	40.8	38.9	42.2	57.2
18/07/2019	20:00	41.9	38.3	43.8	57.9
18/07/2019	20:15	41.2	37.7	43.5	52.9
18/07/2019	20:30	42.9	38.0	45.6	57.1
18/07/2019	20:45	40.8	37.2	43.5	53.6
18/07/2019	21:00	43.0	36.9	43.2	61.3
18/07/2019	21:15	42.6	38.3	42.3	62.6
18/07/2019	21:30	43.0	38.3	42.3	61.5
18/07/2019	21:45	43.0	38.0	45.6	58.5
18/07/2019	22:00	41.1	37.8	44.0	53.8
18/07/2019	22:15	42.3	38.0	43.0	57.3
18/07/2019	22:30	39.0	36.8	39.7	54.1
18/07/2019	22:45	37.9	36.6	39.0	44.1
18/07/2019	23:00	38.1	36.8	39.3	45.2
18/07/2019	23:15	40.7	37.8	40.6	54.2
18/07/2019	23:30	41.4	36.4	39.9	58.2
18/07/2019	23:45	38.2	36.1	39.4	49.7
19/07/2019	00:00	41.7	35.8	39.3	59.1
19/07/2019	00:15	37.0	35.6	38.2	47.8
19/07/2019	00:30	36.9	35.6	38.0	45.3
19/07/2019	00:45	39.8	35.6	39.0	56.9
19/07/2019	01:00	36.5	34.7	37.7	41.3
19/07/2019	01:15	35.0	33.7	36.2	39.9
19/07/2019	01:30	35.7	33.9	37.1	46.2
19/07/2019	01:45	35.4	33.3	37.1	47.6
19/07/2019	02:00	35.0	33.8	36.2	39.1
19/07/2019	02:15	37.2	34.2	37.7	50.8
19/07/2019	02:30	35.6	33.9	37.0	44.5
19/07/2019	02:45	36.3	34.9	37.4	41.2
19/07/2019	03:00	41.0	34.5	38.2	57.1

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
19/07/2019	03:15	47.4	33.6	41.7	64.1
19/07/2019	03:30	34.1	32.9	35.1	39.8
19/07/2019	03:45	35.0	33.4	36.2	42.0
19/07/2019	04:00	35.0	33.5	36.1	44.0
19/07/2019	04:15	39.8	34.2	38.3	62.1
19/07/2019	04:30	43.2	34.7	43.8	61.9
19/07/2019	04:45	38.7	35.2	40.8	53.9
19/07/2019	05:00	39.7	36.2	42.5	53.5
19/07/2019	05:15	41.0	36.9	43.7	54.5
19/07/2019	05:30	42.1	38.7	43.6	58.2
19/07/2019	05:45	42.2	39.2	42.5	58.2
19/07/2019	06:00	42.8	39.5	43.9	65.9
19/07/2019	06:15	44.5	39.8	47.7	54.5
19/07/2019	06:30	45.5	40.3	48.9	56.1
19/07/2019	06:45	47.4	42.0	49.4	72.4
19/07/2019	07:00	46.7	42.0	48.7	66.2
19/07/2019	07:15	51.3	43.0	52.9	75.5
19/07/2019	07:30	45.9	43.0	47.4	59.4
19/07/2019	07:45	46.1	42.9	48.3	58.5
19/07/2019	08:00	46.0	42.6	47.5	60.3
19/07/2019	08:15	46.0	42.2	49.2	56.8
19/07/2019	08:30	45.7	42.4	48.3	59.1
19/07/2019	08:45	45.4	42.4	46.9	60.9
19/07/2019	09:00	46.3	42.9	49.0	61.5
19/07/2019	09:15	46.9	43.0	49.6	63.5
19/07/2019	09:30	53.3	43.5	47.7	75.9
19/07/2019	09:45	46.5	43.8	47.6	62.0
19/07/2019	10:00	47.3	43.7	49.5	63.2
19/07/2019	10:15	47.9	44.8	49.5	60.0
19/07/2019	10:30	47.1	44.8	48.5	64.0
19/07/2019	10:45	48.6	45.3	51.0	70.9
19/07/2019	11:00	55.0	51.3	56.7	69.0
19/07/2019	11:15	56.1	52.2	57.8	70.9
19/07/2019	11:30	49.8	47.2	51.5	64.5

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
19/07/2019	11:45	48.8	47.3	49.9	62.1
19/07/2019	12:00	49.6	47.5	50.8	66.3
19/07/2019	12:15	49.3	47.7	50.6	57.4
19/07/2019	12:30	49.9	48.5	51.0	55.1
19/07/2019	12:45	49.3	47.4	50.6	57.5
19/07/2019	13:00	49.1	46.8	50.7	58.5
19/07/2019	13:15	48.0	45.2	49.5	58.3
19/07/2019	13:30	48.1	45.2	49.4	62.9
19/07/2019	13:45	48.1	46.1	49.4	62.1
19/07/2019	14:00	48.7	46.7	50.1	58.6
19/07/2019	14:15	48.7	47.1	49.9	55.4
19/07/2019	14:30	48.5	46.8	49.8	63.1
19/07/2019	14:45	48.0	46.1	49.1	68.3
19/07/2019	15:00	47.7	45.5	49.1	58.0
19/07/2019	15:15	48.2	45.8	49.5	65.0
19/07/2019	15:30	48.2	45.8	48.8	65.2
19/07/2019	15:45	47.3	45.4	48.4	59.8
19/07/2019	16:00	48.0	45.8	49.3	61.9
19/07/2019	16:15	48.2	46.2	49.5	62.8
19/07/2019	16:30	48.5	45.9	50.2	57.3
19/07/2019	16:45	46.7	45.1	47.8	57.3
19/07/2019	17:00	47.5	45.3	48.4	68.4
19/07/2019	17:15	47.2	44.9	48.0	72.6
19/07/2019	17:30	45.8	43.9	47.2	54.8
19/07/2019	17:45	47.2	44.8	49.0	61.8
19/07/2019	18:00	47.3	44.5	48.8	68.2
19/07/2019	18:15	47.2	44.5	49.0	57.5
19/07/2019	18:30	47.6	44.9	49.5	66.6
19/07/2019	18:45	45.9	43.9	47.3	62.7
19/07/2019	19:00	46.6	44.7	47.8	57.6
19/07/2019	19:15	47.0	45.2	48.2	59.9
19/07/2019	19:30	46.5	44.1	47.8	65.7
19/07/2019	19:45	46.0	44.4	47.1	58.1
19/07/2019	20:00	46.4	44.5	47.8	59.0

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
19/07/2019	20:15	46.0	43.7	47.6	57.4
19/07/2019	20:30	45.8	43.5	47.0	57.4
19/07/2019	20:45	44.9	42.9	46.4	54.9
19/07/2019	21:00	45.5	43.3	47.3	58.1
19/07/2019	21:15	44.6	42.6	46.0	55.4
19/07/2019	21:30	43.9	42.4	45.1	50.9
19/07/2019	21:45	44.0	42.4	45.2	49.8
19/07/2019	22:00	44.2	42.1	45.8	55.8
19/07/2019	22:15	42.9	40.7	44.5	50.5
19/07/2019	22:30	43.0	41.1	44.2	53.5
19/07/2019	22:45	43.7	40.7	45.5	59.1
19/07/2019	23:00	42.5	39.9	44.1	57.3
19/07/2019	23:15	41.9	38.6	44.2	57.0
19/07/2019	23:30	41.0	39.3	42.2	53.1
19/07/2019	23:45	40.9	38.8	41.9	51.8
20/07/2019	00:00	41.1	39.3	42.4	49.8
20/07/2019	00:15	42.4	40.2	43.7	54.1
20/07/2019	00:30	42.9	40.9	44.1	57.4
20/07/2019	00:45	42.0	40.4	43.3	51.5
20/07/2019	01:00	41.9	39.8	43.5	52.7
20/07/2019	01:15	43.2	41.0	45.0	53.2
20/07/2019	01:30	41.4	39.4	42.7	51.3
20/07/2019	01:45	47.9	39.7	52.1	66.0
20/07/2019	02:00	51.2	47.0	53.6	65.9
20/07/2019	02:15	51.0	43.2	54.6	67.0
20/07/2019	02:30	41.2	39.2	43.0	54.8
20/07/2019	02:45	39.8	37.5	41.4	46.8
20/07/2019	03:00	37.7	35.7	39.3	45.4
20/07/2019	03:15	39.0	36.7	40.8	49.3
20/07/2019	03:30	38.2	36.2	39.6	46.7
20/07/2019	03:45	39.3	37.6	40.7	48.3
20/07/2019	04:00	40.7	38.9	42.0	46.1
20/07/2019	04:15	42.4	40.4	43.9	57.0
20/07/2019	04:30	44.6	40.3	46.5	62.0

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	04:45	43.2	40.1	45.5	59.7
20/07/2019	05:00	42.2	40.2	43.7	49.5
20/07/2019	05:15	45.4	40.9	47.4	58.7
20/07/2019	05:30	43.5	40.2	45.0	58.0
20/07/2019	05:45	43.9	41.5	45.8	52.2
20/07/2019	06:00	44.6	42.0	46.3	56.2
20/07/2019	06:15	44.4	41.8	45.7	62.3
20/07/2019	06:30	45.8	42.7	47.9	57.7
20/07/2019	06:45	46.0	43.5	47.6	60.2
20/07/2019	07:00	45.7	42.5	47.9	63.3
20/07/2019	07:15	45.5	42.4	48.0	57.9
20/07/2019	07:30	44.5	42.5	46.0	57.8
20/07/2019	07:45	45.5	42.7	47.4	57.9
20/07/2019	08:00	46.9	42.9	49.0	60.0
20/07/2019	08:15	46.8	44.0	49.1	59.7
20/07/2019	08:30	45.7	43.4	47.3	57.1
20/07/2019	08:45	46.7	43.7	48.5	62.0
20/07/2019	09:00	47.2	43.7	48.9	69.3
20/07/2019	09:15	46.5	44.1	48.1	62.4
20/07/2019	09:30	46.4	43.8	48.2	60.7
20/07/2019	09:45	46.6	44.3	48.4	61.2
20/07/2019	10:00	45.8	43.3	47.5	56.1
20/07/2019	10:15	47.9	45.1	49.6	62.5
20/07/2019	10:30	49.6	45.0	51.1	67.1
20/07/2019	10:45	48.1	45.6	49.7	64.4
20/07/2019	11:00	47.2	45.0	48.1	62.7
20/07/2019	11:15	49.2	45.4	49.7	78.2
20/07/2019	11:30	48.2	45.2	49.8	64.6
20/07/2019	11:45	48.8	45.4	49.7	66.6
20/07/2019	12:00	47.9	45.8	49.2	58.6
20/07/2019	12:15	49.6	47.4	51.1	63.8
20/07/2019	12:30	50.7	47.3	52.8	62.5
20/07/2019	12:45	51.4	48.1	54.0	59.5
20/07/2019	13:00	48.8	46.1	50.9	59.7

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	13:15	48.2	46.2	49.6	55.3
20/07/2019	13:30	49.7	47.1	50.7	71.8
20/07/2019	13:45	49.4	45.6	51.9	59.2
20/07/2019	14:00	48.2	45.7	49.7	56.2
20/07/2019	14:15	48.7	46.0	50.4	60.0
20/07/2019	14:30	48.4	45.8	50.0	57.5
20/07/2019	14:45	48.3	45.6	50.1	64.2
20/07/2019	15:00	48.5	46.5	50.2	59.1
20/07/2019	15:15	48.8	46.4	50.5	60.8
20/07/2019	15:30	50.8	46.6	52.1	71.7
20/07/2019	15:45	49.9	47.3	51.6	62.2
20/07/2019	16:00	49.0	46.3	50.9	58.8
20/07/2019	16:15	49.1	46.1	51.0	60.6
20/07/2019	16:30	49.4	46.4	51.3	63.2
20/07/2019	16:45	48.3	45.6	49.9	61.0
20/07/2019	17:00	47.9	45.1	50.0	57.9
20/07/2019	17:15	46.6	44.4	48.0	60.9
20/07/2019	17:30	48.0	45.3	49.5	65.3
20/07/2019	17:45	47.1	44.8	48.5	64.4
20/07/2019	18:00	47.3	45.0	48.9	59.9
20/07/2019	18:15	48.4	45.5	50.5	61.0
20/07/2019	18:30	47.6	44.6	49.6	58.7
20/07/2019	18:45	47.4	43.7	49.1	61.1
20/07/2019	19:00	47.0	44.2	48.2	66.6
20/07/2019	19:15	45.9	43.3	47.7	58.9
20/07/2019	19:30	46.6	43.7	48.3	60.0
20/07/2019	19:45	44.7	42.6	46.1	55.8
20/07/2019	20:00	45.5	42.4	47.8	61.0
20/07/2019	20:15	45.2	42.3	47.4	59.5
20/07/2019	20:30	43.7	41.1	45.2	56.4
20/07/2019	20:45	44.7	41.0	44.5	62.8
20/07/2019	21:00	44.5	41.5	46.0	60.7
20/07/2019	21:15	43.5	40.4	45.8	57.8
20/07/2019	21:30	44.4	39.3	47.7	60.6

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
20/07/2019	21:45	44.7	40.9	46.8	62.1
20/07/2019	22:00	44.1	41.3	45.1	58.9
20/07/2019	22:15	45.1	41.1	46.9	58.1
20/07/2019	22:30	43.2	40.9	44.5	56.3
20/07/2019	22:45	44.3	40.2	45.5	59.0
20/07/2019	23:00	42.7	40.0	44.1	56.4
20/07/2019	23:15	41.0	39.4	42.2	49.0
20/07/2019	23:30	42.5	38.7	42.6	59.0
20/07/2019	23:45	38.9	37.3	40.1	48.4
21/07/2019	00:00	38.0	36.9	39.1	47.0
21/07/2019	00:15	43.2	36.6	43.5	58.7
21/07/2019	00:30	38.6	36.7	39.9	54.8
21/07/2019	00:45	37.5	36.2	38.6	49.7
21/07/2019	01:00	37.6	36.5	38.5	42.0
21/07/2019	01:15	38.1	36.6	39.5	44.9
21/07/2019	01:30	37.9	36.6	39.0	46.0
21/07/2019	01:45	38.3	36.6	39.7	46.1
21/07/2019	02:00	36.5	34.8	37.7	45.7
21/07/2019	02:15	36.0	34.8	36.9	52.0
21/07/2019	02:30	35.9	34.8	36.8	44.4
21/07/2019	02:45	37.9	35.3	37.6	56.3
21/07/2019	03:00	36.2	35.1	37.1	41.5
21/07/2019	03:15	36.2	34.7	37.6	40.0
21/07/2019	03:30	35.7	34.4	36.6	41.8
21/07/2019	03:45	35.6	34.2	36.2	53.0
21/07/2019	04:00	36.8	35.0	37.8	53.9
21/07/2019	04:15	41.5	35.5	45.0	57.6
21/07/2019	04:30	40.2	35.3	39.7	62.3
21/07/2019	04:45	36.9	35.3	38.1	47.8
21/07/2019	05:00	41.2	36.5	43.6	55.0
21/07/2019	05:15	42.4	37.0	44.2	58.3
21/07/2019	05:30	41.0	36.7	41.2	60.0
21/07/2019	05:45	39.2	36.8	40.6	52.1
21/07/2019	06:00	41.9	38.0	43.0	60.1

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
21/07/2019	06:15	43.8	37.7	46.4	57.5
21/07/2019	06:30	43.4	36.9	45.6	59.0
21/07/2019	06:45	42.1	37.0	44.6	57.5
21/07/2019	07:00	48.2	36.3	47.1	74.6
21/07/2019	07:15	44.8	36.9	48.9	66.4
21/07/2019	07:30	45.0	38.2	48.8	58.8
21/07/2019	07:45	45.4	37.4	48.1	61.2
21/07/2019	08:00	43.5	36.7	46.5	59.8
21/07/2019	08:15	47.4	37.1	50.0	67.7
21/07/2019	08:30	44.3	37.7	47.8	61.7
21/07/2019	08:45	47.3	38.5	50.9	62.3
21/07/2019	09:00	44.7	37.5	47.6	63.6
21/07/2019	09:15	43.9	38.4	47.3	60.4
21/07/2019	09:30	47.3	38.6	44.5	68.2
21/07/2019	09:45	46.0	40.1	46.9	64.3
21/07/2019	10:00	45.7	42.1	48.4	58.7
21/07/2019	10:15	45.3	42.1	46.9	59.0
21/07/2019	10:30	46.3	41.9	47.4	62.7
21/07/2019	10:45	44.7	42.4	46.2	57.5
21/07/2019	11:00	43.9	41.8	45.6	53.0
21/07/2019	11:15	44.6	41.2	46.8	56.5
21/07/2019	11:30	45.2	42.0	47.3	58.4
21/07/2019	11:45	45.3	42.2	46.5	61.9
21/07/2019	12:00	45.2	42.9	46.5	58.7
21/07/2019	12:15	46.1	43.2	47.5	59.2
21/07/2019	12:30	44.5	42.8	45.7	57.1
21/07/2019	12:45	47.0	43.3	48.3	68.0
21/07/2019	13:00	45.6	42.6	47.8	57.2
21/07/2019	13:15	45.6	43.2	46.9	57.8
21/07/2019	13:30	45.2	42.5	47.1	54.1
21/07/2019	13:45	45.6	43.0	47.0	59.4
21/07/2019	14:00	45.2	41.9	47.3	59.5
21/07/2019	14:15	44.5	41.3	46.1	59.2
21/07/2019	14:30	46.4	43.3	47.6	62.7

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
21/07/2019	14:45	46.3	43.2	48.5	57.0
21/07/2019	15:00	47.5	44.0	49.7	61.3
21/07/2019	15:15	46.4	44.0	47.8	61.3
21/07/2019	15:30	45.9	43.5	47.1	65.9
21/07/2019	15:45	48.3	43.5	50.7	64.3
21/07/2019	16:00	46.8	44.4	48.7	56.9
21/07/2019	16:15	46.7	44.1	48.0	60.5
21/07/2019	16:30	47.4	44.0	48.6	63.9
21/07/2019	16:45	46.6	42.5	49.1	60.2
21/07/2019	17:00	46.6	43.4	48.9	58.3
21/07/2019	17:15	45.7	42.1	47.8	63.8
21/07/2019	17:30	47.0	42.8	47.7	66.3
21/07/2019	17:45	46.8	43.6	49.1	59.4
21/07/2019	18:00	46.6	43.5	48.2	60.2
21/07/2019	18:15	46.0	42.9	48.0	62.7
21/07/2019	18:30	46.7	43.3	48.4	61.4
21/07/2019	18:45	46.9	43.9	49.2	56.8
21/07/2019	19:00	46.4	43.4	47.6	63.7
21/07/2019	19:15	47.3	43.6	48.8	62.0
21/07/2019	19:30	46.0	43.7	47.5	55.7
21/07/2019	19:45	46.4	43.3	48.0	58.0
21/07/2019	20:00	46.0	43.7	47.6	56.1
21/07/2019	20:15	47.0	42.8	48.8	62.7
21/07/2019	20:30	45.7	42.0	47.2	61.6
21/07/2019	20:45	44.7	42.2	46.5	58.6
21/07/2019	21:00	44.7	42.1	46.1	56.0
21/07/2019	21:15	43.7	41.6	45.1	54.5
21/07/2019	21:30	44.5	40.8	46.3	59.1
21/07/2019	21:45	43.7	40.6	45.1	56.9
21/07/2019	22:00	44.1	40.7	44.5	61.2
21/07/2019	22:15	43.5	40.6	43.9	58.9
21/07/2019	22:30	43.8	40.3	44.4	58.9
21/07/2019	22:45	45.9	40.9	47.7	64.9
21/07/2019	23:00	43.8	41.0	45.8	52.6

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
21/07/2019	23:15	45.9	40.6	47.2	61.1
21/07/2019	23:30	43.4	40.2	43.7	59.2
21/07/2019	23:45	42.3	39.6	43.9	54.2
22/07/2019	00:00	41.4	39.2	43.1	48.8
22/07/2019	00:15	41.2	39.3	42.5	52.4
22/07/2019	00:30	41.5	39.2	43.2	49.6
22/07/2019	00:45	45.2	39.7	44.9	70.6
22/07/2019	01:00	41.4	39.1	42.9	50.9
22/07/2019	01:15	42.0	39.2	44.0	49.5
22/07/2019	01:30	44.2	39.9	46.7	59.2
22/07/2019	01:45	41.3	38.3	43.4	52.0
22/07/2019	02:00	40.4	38.2	42.0	47.3
22/07/2019	02:15	40.2	38.0	41.9	47.3
22/07/2019	02:30	40.4	37.6	41.8	56.9
22/07/2019	02:45	40.6	38.1	42.3	51.2
22/07/2019	03:00	40.5	38.4	42.4	50.7
22/07/2019	03:15	40.2	37.7	41.9	47.9
22/07/2019	03:30	40.5	38.2	42.0	51.8
22/07/2019	03:45	40.5	37.8	42.5	50.1
22/07/2019	04:00	39.8	37.7	41.4	46.8
22/07/2019	04:15	41.1	38.3	43.1	57.1
22/07/2019	04:30	43.0	38.6	45.9	55.3
22/07/2019	04:45	41.6	38.4	43.0	57.5
22/07/2019	05:00	43.4	39.0	44.3	61.1
22/07/2019	05:15	45.5	41.2	48.4	56.8
22/07/2019	05:30	43.9	41.3	45.4	56.0
22/07/2019	05:45	45.0	43.0	46.3	54.7
22/07/2019	06:00	45.2	43.3	46.6	57.2
22/07/2019	06:15	46.6	43.8	48.2	56.1
22/07/2019	06:30	48.5	45.3	51.0	59.2
22/07/2019	06:45	47.5	45.2	48.7	60.7
22/07/2019	07:00	48.8	45.6	51.1	62.2
22/07/2019	07:15	47.3	45.3	48.7	57.7
22/07/2019	07:30	46.6	44.2	48.1	59.2

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
22/07/2019	07:45	47.2	45.1	48.6	68.9
22/07/2019	08:00	47.1	44.9	48.8	62.2
22/07/2019	08:15	47.4	44.7	49.2	59.7
22/07/2019	08:30	47.0	45.0	48.5	57.8
22/07/2019	08:45	48.6	45.1	49.6	69.3
22/07/2019	09:00	49.3	44.7	49.2	69.9
22/07/2019	09:15	46.9	44.5	48.8	56.3
22/07/2019	09:30	47.7	45.2	49.4	60.4
22/07/2019	09:45	47.2	45.3	48.7	60.1
22/07/2019	10:00	47.5	44.6	48.7	64.7
22/07/2019	10:15	46.2	44.2	47.3	63.5
22/07/2019	10:30	45.6	43.4	46.8	60.3
22/07/2019	10:45	45.8	43.6	47.5	53.5
22/07/2019	11:00	47.3	43.4	49.4	61.6
22/07/2019	11:15	44.9	42.7	46.7	52.7
22/07/2019	11:30	45.2	42.7	46.2	59.0
22/07/2019	11:45	44.2	42.0	45.9	56.1
22/07/2019	12:00	48.3	42.3	47.1	67.4
22/07/2019	12:15	44.5	42.4	45.9	55.6
22/07/2019	12:30	46.5	42.5	49.4	58.8
22/07/2019	12:45	46.2	43.2	48.0	54.6
22/07/2019	13:00	44.6	42.3	46.0	60.9
22/07/2019	13:15	47.5	42.7	47.7	62.2
22/07/2019	13:30	49.7	42.7	52.3	68.0
22/07/2019	13:45	47.7	43.2	51.0	62.4
22/07/2019	14:00	47.0	42.4	51.4	58.0
22/07/2019	14:15	43.6	41.3	45.0	55.6
22/07/2019	14:30	44.6	42.1	46.4	56.9
22/07/2019	14:45	44.0	41.7	44.9	57.9
22/07/2019	15:00	45.1	42.2	47.1	59.4
22/07/2019	15:15	44.4	41.2	45.3	62.0
22/07/2019	15:30	43.9	41.5	45.4	57.0
22/07/2019	15:45	43.5	41.5	44.7	54.5
22/07/2019	16:00	44.5	41.8	45.5	60.3

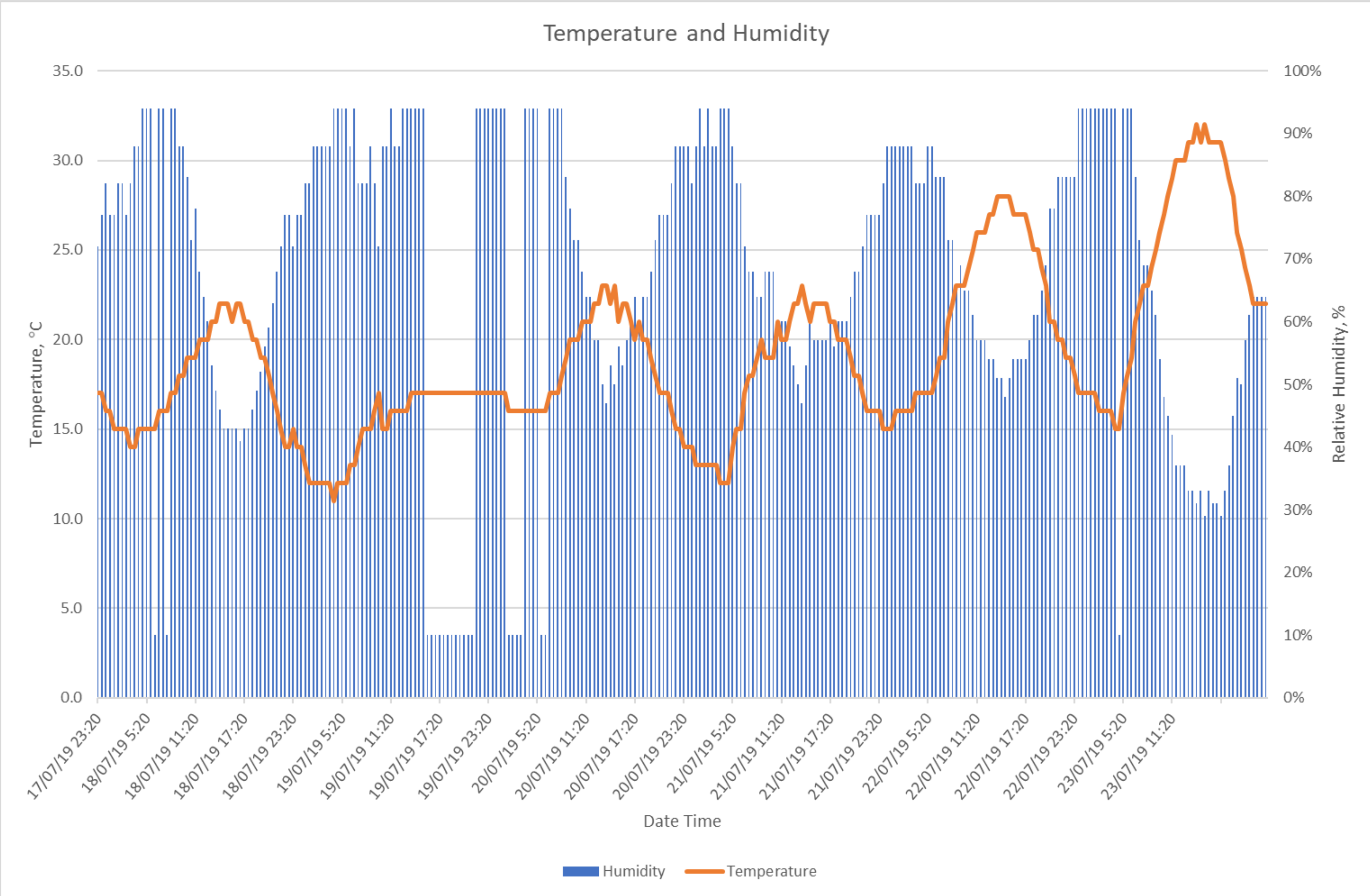
Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
22/07/2019	16:15	44.0	40.5	45.5	59.0
22/07/2019	16:30	44.8	41.3	46.1	65.0
22/07/2019	16:45	44.6	41.0	45.9	59.5
22/07/2019	17:00	45.7	41.8	48.2	57.8
22/07/2019	17:15	44.6	41.5	46.3	57.8
22/07/2019	17:30	44.5	41.8	46.6	62.2
22/07/2019	17:45	46.0	41.3	47.8	62.2
22/07/2019	18:00	44.3	40.7	46.3	58.8
22/07/2019	18:15	44.7	41.3	47.0	57.1
22/07/2019	18:30	45.0	41.3	46.8	59.3
22/07/2019	18:45	44.1	40.8	45.3	57.9
22/07/2019	19:00	45.5	42.0	47.7	59.0
22/07/2019	19:15	45.8	41.5	48.2	57.8
22/07/2019	19:30	43.8	40.4	45.5	57.5
22/07/2019	19:45	43.1	40.3	44.1	57.3
22/07/2019	20:00	41.4	39.1	43.1	51.9
22/07/2019	20:15	43.5	40.2	46.4	54.9
22/07/2019	20:30	43.0	39.5	45.1	54.4
22/07/2019	20:45	42.5	39.1	45.1	57.5
22/07/2019	21:00	42.1	38.6	44.5	55.0
22/07/2019	21:15	40.2	37.2	42.4	54.6
22/07/2019	21:30	40.5	37.3	41.4	55.4
22/07/2019	21:45	38.6	36.8	40.2	54.5
22/07/2019	22:00	43.4	37.5	45.8	60.3
22/07/2019	22:15	45.0	38.1	49.2	57.7
22/07/2019	22:30	42.6	36.9	41.8	58.3
22/07/2019	22:45	39.7	36.8	40.5	57.0
22/07/2019	23:00	41.9	36.1	40.6	57.0
22/07/2019	23:15	46.7	36.5	47.6	64.6
22/07/2019	23:30	41.0	35.5	38.0	59.4
22/07/2019	23:45	36.4	35.0	37.2	44.6
23/07/2019	00:00	36.3	35.0	37.2	47.4
23/07/2019	00:15	34.9	34.0	35.6	41.8
23/07/2019	00:30	35.6	34.3	36.9	47.9

Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
23/07/2019	00:45	35.1	34.3	35.9	41.8
23/07/2019	01:00	39.8	34.2	37.2	55.1
23/07/2019	01:15	35.2	34.2	35.9	43.7
23/07/2019	01:30	36.0	35.0	36.8	41.3
23/07/2019	01:45	36.0	34.8	37.0	40.7
23/07/2019	02:00	36.9	33.8	36.9	49.9
23/07/2019	02:15	35.4	34.3	36.2	45.6
23/07/2019	02:30	36.2	34.7	37.2	49.2
23/07/2019	02:45	35.2	34.1	36.4	39.5
23/07/2019	03:00	35.8	34.4	36.9	45.6
23/07/2019	03:15	36.6	35.3	37.7	47.3
23/07/2019	03:30	36.7	35.3	38.0	42.6
23/07/2019	03:45	37.3	35.5	38.6	45.2
23/07/2019	04:00	37.9	35.6	38.6	56.3
23/07/2019	04:15	42.5	35.8	46.0	57.8
23/07/2019	04:30	40.6	37.4	42.8	53.5
23/07/2019	04:45	41.5	38.9	43.4	53.2
23/07/2019	05:00	45.6	42.7	48.1	54.0
23/07/2019	05:15	49.2	47.6	50.2	60.9
23/07/2019	05:30	47.6	46.2	48.8	55.7
23/07/2019	05:45	48.8	46.4	48.3	69.2
23/07/2019	06:00	48.9	47.3	50.8	58.5
23/07/2019	06:15	50.2	48.7	51.4	60.1
23/07/2019	06:30	53.5	51.5	54.9	58.7
23/07/2019	06:45	52.4	50.2	53.8	59.6
23/07/2019	07:00	49.0	46.9	50.3	56.3
23/07/2019	07:15	47.7	43.5	49.7	64.3
23/07/2019	07:30	42.7	39.9	44.7	54.5
23/07/2019	07:45	44.4	40.2	46.8	59.5
23/07/2019	08:00	43.5	41.2	44.8	57.6
23/07/2019	08:15	42.7	40.7	44.3	59.4
23/07/2019	08:30	43.7	41.0	44.9	58.4
23/07/2019	08:45	43.4	40.6	44.1	60.7
23/07/2019	09:00	44.5	41.0	44.4	74.3

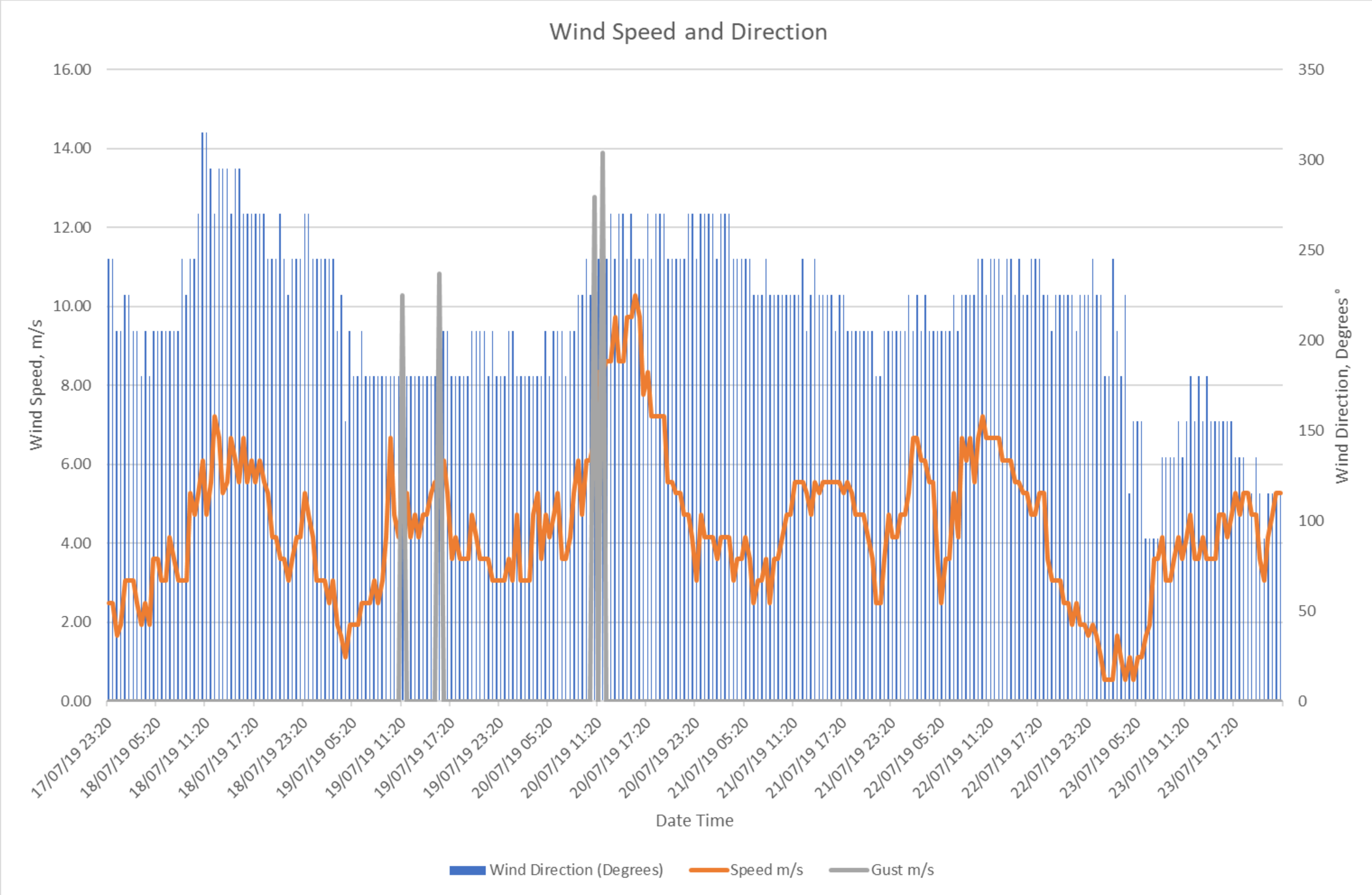
Date	Time	L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}
23/07/2019	09:15	43.4	40.4	44.5	59.3
23/07/2019	09:30	59.2	41.2	65.2	71.7
23/07/2019	09:45	51.3	39.7	52.8	66.8
23/07/2019	10:00	53.3	39.8	46.3	85.8

APPENDIX 03

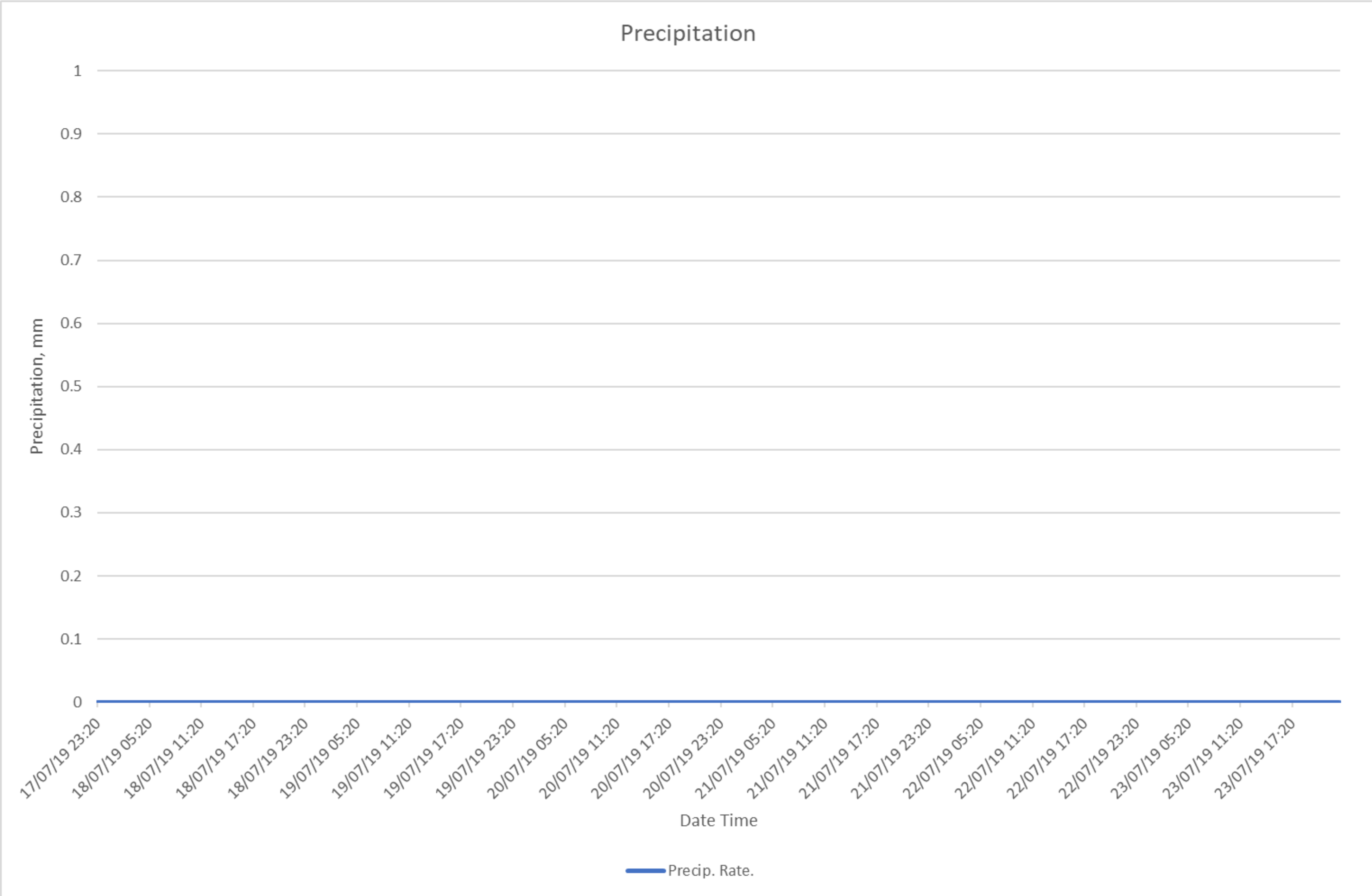
Weather Data



Temperature and Humidity
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Temperature, °C
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Relative Humidity, %
17/07/19 23:20
18/07/19 5:20
18/07/19 11:20
18/07/19 17:20
18/07/19 23:20
19/07/19 5:20
19/07/19 11:20
19/07/19 17:20
19/07/19 23:20
20/07/19 5:20
20/07/19 11:20
20/07/19 17:20
20/07/19 23:20
21/07/19 5:20
21/07/19 11:20
21/07/19 17:20
21/07/19 23:20
22/07/19 5:20
22/07/19 11:20
22/07/19 17:20
22/07/19 23:20
23/07/19 5:20
23/07/19 11:20
Date Time
Humidity
Temperature



Wind Speed and Direction
Wind Speed, m/s
Wind Direction, Degrees °
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
350
300
250
200
150
100
50
0
17/07/19 23:20
18/07/19 05:20
18/07/19 11:20
18/07/19 17:20
18/07/19 23:20
19/07/19 05:20
19/07/19 11:20
19/07/19 17:20
19/07/19 23:20
20/07/19 05:20
20/07/19 11:20
20/07/19 17:20
20/07/19 23:20
21/07/19 05:20
21/07/19 11:20
21/07/19 17:20
21/07/19 23:20
22/07/19 05:20
22/07/19 11:20
22/07/19 17:20
22/07/19 23:20
23/07/19 05:20
23/07/19 11:20
23/07/19 17:20
Date Time
Wind Direction (Degrees)
Speed m/s
Gust m/s



Precipitation
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Precipitation, mm
17/07/19 23:20
18/07/19 05:20
18/07/19 11:20
18/07/19 17:20
18/07/19 23:20
19/07/19 05:20
19/07/19 11:20
19/07/19 17:20
19/07/19 23:20
20/07/19 05:20
20/07/19 11:20
20/07/19 17:20
20/07/19 23:20
21/07/19 05:20
21/07/19 11:20
21/07/19 17:20
21/07/19 23:20
22/07/19 05:20
22/07/19 11:20
22/07/19 17:20
22/07/19 23:20
23/07/19 05:20
23/07/19 11:20
23/07/19 17:20
Date Time
Precip. Rate.

APPENDIX 04

SBG Locations

Table 02-2
Measured Noise Levels at Location 2, free-field, dB

SBG Reference	SBG Model	Coordinates (X, Y)
Campus	X185CMTU	507977, 208246
		507980, 208233
		507980, 208231
		507981, 208228
		507981, 208225
		507985, 208205
		507985, 208202
		507987, 208190
		507987, 208187
		507988, 208185
		507989, 208182
		507992, 208162
		507993, 208154
		507994, 208152
		507996, 208139
		507996, 208136
		507996, 208134
		507997, 208131
		508022, 208135
		508021, 208140
		508020, 208143
		508018, 208156
		508017, 208159
		508012, 208191
		508012, 208194
		508009, 208206
		508009, 208208
		508006, 208229
		508005, 208232
		508004, 208237
		508005, 208235
Centro	X1000MTU	508145, 208416
		508145, 208412
		508145, 208409
		508145, 208406
HH4	KOHLER T2500	508459, 207679
		508460, 207676
		508461, 207673

SBG Reference	SBG Model	Coordinates (X, Y)
		508462, 207670
		508463, 207667
		508470, 207646
		508472, 207643
		508473, 207639
		508474, 207636
		508475, 207633
		508482, 207612
		508483, 207609
		508484, 207606
		508485, 207603
		508487, 207599
		508464, 207663
		508466, 207660
		508467, 207657
		508468, 207654
		508469, 207651
		508457, 207684
		508456, 207687
		508476, 207630
		508480, 207617
		508477, 207626
		508479, 207620
		508478, 207623
		508455, 207690
Maylands	X1000MTU	507501, 208467
		507495, 208463
		507492, 208461
		507459, 208453
		507525, 208458
		507522, 208456
		507518, 208452
		507515, 208450
		507511, 208448
		507508, 208446
		507516, 208471
		507505, 208470
		507513, 208469
		507461, 208450

APPENDIX 05

Supplementary Acoustic Report – SBG Specifications

Ref: 19033/008/dd

Date: 21 August 2020

AAD

applied acoustic design

NTT HH4 DATA CENTRE

ACOUSTIC SPECIFICATION

THE GREEN BUSINESS CENTRE
THE CAUSEWAY
STAINES
MIDDLESEX
TW18 3AL

TELEPHONE: 01784 464404
FACSIMILE: 01784 465447
E MAIL: mail@aad.co.uk

DOCUMENT CONTROL SHEET

Issue	Date	Reason	Issued By	Approved By
A	21/08/20	Tender	DD/PW	PW

CONTENTS

PART 1 - PRELIMINARIES

1.0 Introduction

1.1 This document provides acoustic specifications and explanations of design details, and is intended to clarify the acoustic performance requirements of the project. If there is any doubt over the interpretation of these specifications and details, then the contractor should contact Applied Acoustic Design for clarification.

2.0 Performance

2.1 Airborne Sound Insulation

2.1.1 Partitions, ceilings, doors, windows/glazing, and related junctions and interfaces with each other and with the base building fabric, shall be constructed so as to achieve the following minimum levels of airborne sound insulation.

Interface	Partition Type	Sound Insulation Performance
Crosswalls		
SCU to Flexible Space	IW12	To achieve the noise criterion set out in Section 2.2 below within any adjacent space
SCU to Circulation Space	IW03	
MMR to Breakout Area	IW04	

Interface	Partition Type	Sound Insulation D_w
Front Walls		
Flexible Space	IW03	To achieve the noise criterion set out in Section 2.2 below within any adjacent space
Office	IW02	
MMR to Circulation Space	IW04	
1st Floor Plantroom	IW02	
SCU	IW02/IW03	
Data Hall	IW02/IW03	

2.1.2 Note the values shown above relate to the overall site performance of all installed elements, and are not necessarily directly related to the laboratory performance values of individual elements.

2.1.3 Where specific room types have not been noted in the table above, the relevant performance will be as per the nearest equivalent room and/or partition type.

2.2 Mechanical Services Noise Levels

2.2.1 Noise levels due to mechanical services systems shall not exceed the following;

Area	Noise Level
Data Halls	NR75
SCU Rooms	NR85
Reception	NR40
Circulation Spaces	NR45
Open Plan Offices	NR40
Meeting Rooms / Security Room / Flexible Space	NR35
VC Enabled Meeting Rooms / Flexible Space	NR32
WCs	NR40
Canteen / Restaurant / Breakout	NR40

3.0 Workmanship

3.1 All constructions are designed to achieve the acoustic criteria as scheduled above, and the Contractor shall ensure that the method of construction and general workmanship are of appropriate quality to allow these ratings to be achieved.

4.0 Deleterious Materials

4.1 Under no account shall any materials, being deleterious in themselves, becoming deleterious when used or with the passage of time, becoming deleterious as a result of poor workmanship during construction, becoming deleterious without a level of maintenance which is higher than that which would normally be expected in a building of the type to be under construction, be used for any noise or vibration attenuating products, materials or measures of any description.

4.2 In this respect, deleterious shall include use or combination of materials that might reduce the normal life expectancy of the materials themselves, of the structure to which they are to be incorporated or affixed. In particular no wood-wool slabs shall be used as permanent formwork, not any asbestos products, nor lead or any products incorporating lead, nor any urea formaldehyde, nor products or materials containing fibres of which the average diameter is less than 3 microns and a length of 200 microns or less unless protected by a complete envelope which prevents any fibre migration whilst not degrading acoustic performance to the satisfaction of the Specification and Applied Acoustic Design.

5.0 Contract Interfaces

5.1 The interfaces between work packages are critical to the success of the acoustic design.

5.2 It shall be the responsibility of the main contractor to ensure that all of the interfaces are managed on site properly to ensure the success of the acoustic design. The main contractor shall include in his management team a person to be fully responsible for the coordination of the interfaces between each package, and acoustic issues generally.

5.3 The main contractor shall take due account of all contractual interfaces and responsibilities of individual sub-contractors to ensure that the overall acoustic performance requirements are satisfied.

6.0 Acoustic Testing

6.1 Acoustic commissioning tests will be undertaken upon project completion (or at any other suitable stage during the contract period), and the Contractor shall allow for attendance as necessary in order to assist the Acoustic Consultant in performing these tests (including but not limited to; provision of power supply and silent lighting, lifting facilities for heavy items of test equipment, and scheduling of other works to avoid construction noise interference with acoustic tests). In addition, the Contractor should make allowance for rectification of any defects noted as a result of these tests.

7.0 Certified Performance Data

7.1 Where building elements are subject to specific acoustic performance requirements for either sound insulation or sound absorption, the Contractor shall provide evidence supporting the required performance. Laboratory test data is preferred, however suitable field test data will be accepted at the discretion of Applied Acoustic Design.

7.2 Should laboratory or suitable field acoustic performance information be unavailable or be unrepresentative for the configurations required, or laboratory testing cannot be accommodated, the contractors submittal must be supported by third party calculation of sufficient detail to show attenuation contributions arising from framing and suchlike features. In this event, the Contractor shall be required to promptly undertake laboratory testing and rating to demonstrate conformance of particular test pieces, yet to be selected, within this specification and to make available such substantive evidence to an agreed timescale and at the Contractors cost.

8.0 Acceptance

8.1 Items in the specification requiring acceptance by Applied Acoustic Design shall also be formally accepted or approved by the Architect and/or Mechanical Services Consultant. Acceptance shall be formally made in writing by the Architect, under instruction from Applied Acoustic Design.

8.2 Acceptance by Applied Acoustic Design shall have the following limitations;

8.2.1 When given in respect to samples of materials, workmanship or methods of construction submitted in accordance with the Contract documents shall not be construed as denoting any degree of satisfaction with the materials used in, or in the execution of the Works.

8.2.2 When given in respect of shop drawings or schemes called for by the sub-contract documents or proposed by the Contractor, is only for conformance with the design intent and information given in the Contract documents.

8.3 No approval by Applied Acoustic Design or the Architect or Mechanical Services Consultant shall relieve the Contractor of his responsibilities under the Contract.

PART 2 - ARCHITECTURAL ACOUSTIC SPECIFICATIONS

1.0 Partitions

1.1 Partition types are as detailed in the Architects partition schedules, specifications and drawings.

1.2 Sound insulation performance of each partition type shall be not less than the values set out below, when measured in accordance with BS EN ISO 140-3:1995 and rated in accordance with BS EN ISO 717-1:1997.

Partition Reference	Type	Sound Insulation (1) R_w
IW03	Plasterboard / stud, slab to slab	51 dB
IW12	Plasterboard / stud, slab to slab with independent plasterboard lining*	63 dB
IW02	Plasterboard / stud, slab to slab	51 dB
IW04	Plasterboard / stud, slab to slab	51 dB

*90mm I steel stud with 2 layers of 15mm Soundbloc 75mm mineral wool in cavity

(1) These are laboratory performance values for individual elements, and do not necessarily represent the required site performance – see Part 1, section 2.1 of this specification.
(2) Ratings are only shown for partitions with an acoustic function – for other partitions refer to Architects specification.
(3) If there are any disparities between ratings shown in Architects specification and this document, the ratings in this document shall take precedence.

1.3 The site performance set out in Part 1 Section 2.1 shall be achieved by the complete partitioning system inclusive of all head, floor and external building fabric closer panels, and all panel joints as would normally be installed. The contractor shall guarantee the acoustic performance required, and shall ensure that the method of installation does not allow for site influenced deficiencies to arise so as to compromise acoustic performance, including, but not limited to, the following;

1.3.1 There must be no unsealed gaps or openings.

1.3.2 All service penetrations, socket cut-outs, etc., must be sealed appropriately. See Figure 3 (included at the end of section 2.0 of this specification).

1.3.3 Any over-panels or infill required to close off openings between ceiling bulkheads and facade shall be constructed in the same manner as the partition in order to ensure commensurate acoustic performance.

1.3.4 Slab to slab partitions within ceiling voids shall be constructed up to the inside face of the external façade. Any voids that would otherwise occur between lateral steel beams and façade must be closed off using the same partition construction. Infill using acoustic ceiling void barrier material will not be accepted.

1.3.5 Deflection heads for slab to slab partitions should be achieved using appropriate constructions where sound insulation is important, as per relevant guidance from British Gypsum (or equal) e.g. steel cloaking angles. Apply additional treatment as necessary to achieve the values stated in Part 1, section 2.1 of this specification.

1.3.6 Where fit out partitions intersect, it is important that flanking wall linings are not continuous past the junction of a crosswall in order to mitigate flanking sound transmission. All partitions must be appropriately keyed into one another as per Figure 2 below.

2.0 Suspended Ceilings Systems

2.1 The suspended ceiling system, including lights and all other acoustically weak fittings as are necessary, must offer a minimum weighted normalised level difference as shown below when tested in accordance with BS EN ISO 10848-2:2006 and rated in accordance with BS EN ISO 717-1:2013. Light fittings and other acoustically weak details may require, for example, additional infill, installation of attenuating baffles or boxes.

Room Type	**Sound Insulation Performance, $D_{n,c,w}$**
Open Plan Offices, Meeting Rooms, Boardroom, Corridors	27 dB
Data Halls, WCs	27 dB

2.2 The ceiling system shall incorporate a robust means of accepting up-loads, fixing and sealing from any partition system so as to create an effective airtight and acoustic seal which will be required for all partitions when installed along grid lines nominated by the Architect.

2.3 The room side surfaces of the ceiling tile system shall provide not less than the following minimum sound absorption performance when tested in accordance with BS EN ISO 354:2003.

Location	**Absorption Class**
Open Plan Offices	Class A
Data Halls, WCs	Class C

2.4 The manufacturer and/or supplier shall guarantee the acoustic performance required, and shall ensure that the method of installation follows all manufacturers published statements and does not allow for site influenced deficiencies to arise so as to compromise acoustic performance.

2.5 Note that micro-perforated ceiling systems will not be suitable for open plan office areas.

2.6 A/V and V/C Systems

2.6.1 Ceiling mounted loudspeakers serving A/V and/or V/C systems must be located onto the rear face of the ceiling system. It is not permissible for loudspeakers to be suspended within the ceiling void, remote from the rear face of the ceiling. No speaker shall be located within 1.0m of any partition that forms the boundary of the room served. Loudspeakers shall be highly directional, with minimum rearward radiation. High performance sound insulation covers shall be provided over each loudspeaker within the ceiling void, positioned and sealed so as to keep rearward sound radiation to the minimum possible. N.B. These measures are required to minimise sound transfer between rooms via the ceiling void. See Section 8.0.

3.0 Doors

3.1 Acoustically rated doorsets shall be supplied with performance ratings as detailed below, and shall comprise leaves of specified construction, with matching profiled frames including all seals as necessary. The frame shall be fully sealed into the host structure so as not to compromise potential sound insulation performance.

3.2 Where necessary to achieve the specified acoustic performance, compressible seals shall be provided all round (including threshold), and the door should be normally held closed, by mechanical latch, against these seals in an air tight manner all round.

3.3 The minimum performance of acoustic doors shall be as follows, when tested in accordance with BS EN ISO 10140-2:2010 and rated in accordance with BS EN ISO 717-1:2013. This rating shall apply for doors complete with all furniture, viewing panels, closure mechanisms, locks and fittings, fire ratings and all other such embellishments as may be elsewhere specified including multiple leaf applications.

Door Ref.	Interface	Sound Insulation R_w
TBC	Office to Circulation Space	35 dB
TBC	SCU to Circulation Space	45 dB
TBC	Data Hall to Circulation Space	40 dB
TBC	Circulation Space to Circulation Space	40 dB
TBC	MER, Switch Room, Battery Room to Circulation Space	35 dB

3.4 The manufacturer and/or supplier shall guarantee the acoustic performance required, and the Contractor shall ensure that the method of installation follows all manufacturers published statements and does not allow for site influenced deficiencies to arise so as to compromise acoustic performance.

4.0 Chiller Yard Louvre Backing Plates

4.1 Chiller yard louvre backing plates, as shown on the architect's drawings, must be of a solid imperforate construction and achieve a surface mass of no less than 15 kg/m^2.

applied acoustic design

Figure 1 : Detail for Treatment Around Beams

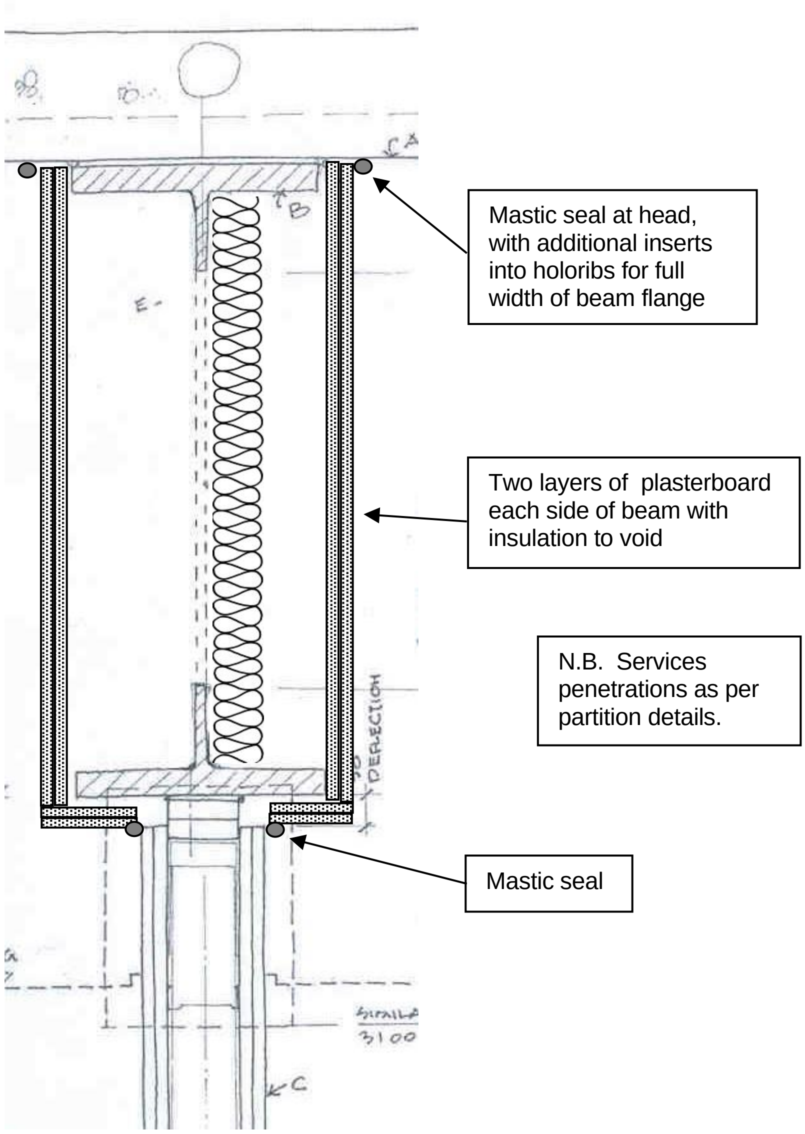
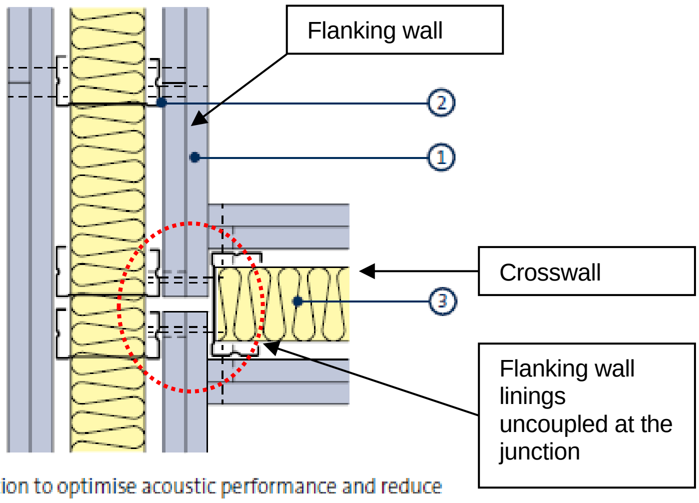


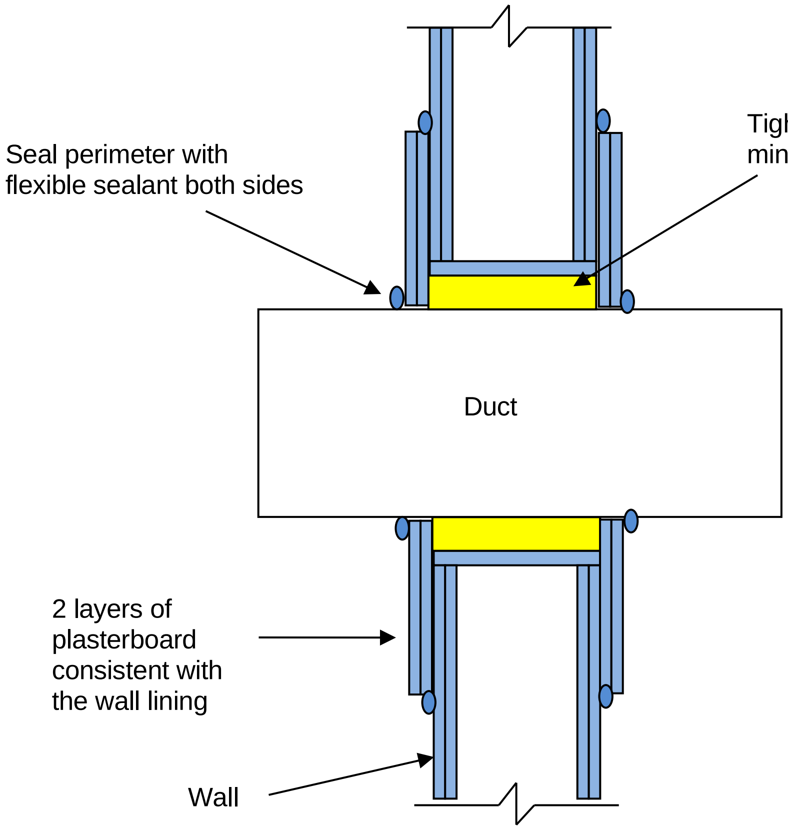
Figure 2 : Detail for Crosswall Junction to Mitigate Flanking Sound Transmission



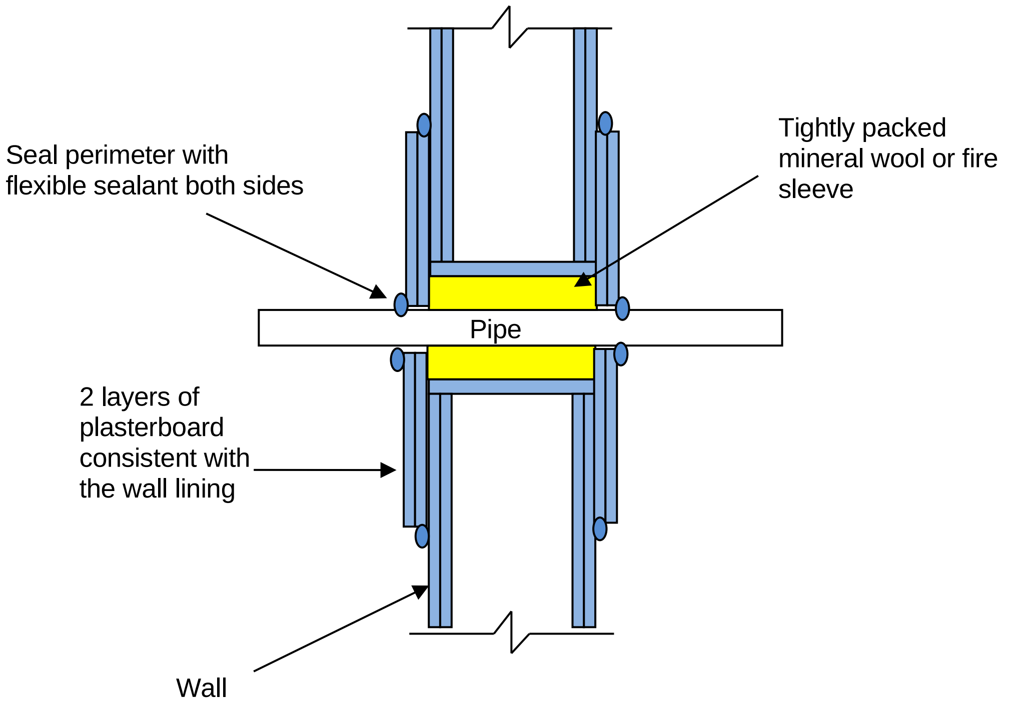
'T' junction to optimise acoustic performance and reduce flanking transmission

Figure 3: Details for Treatment of Partition Penetrations

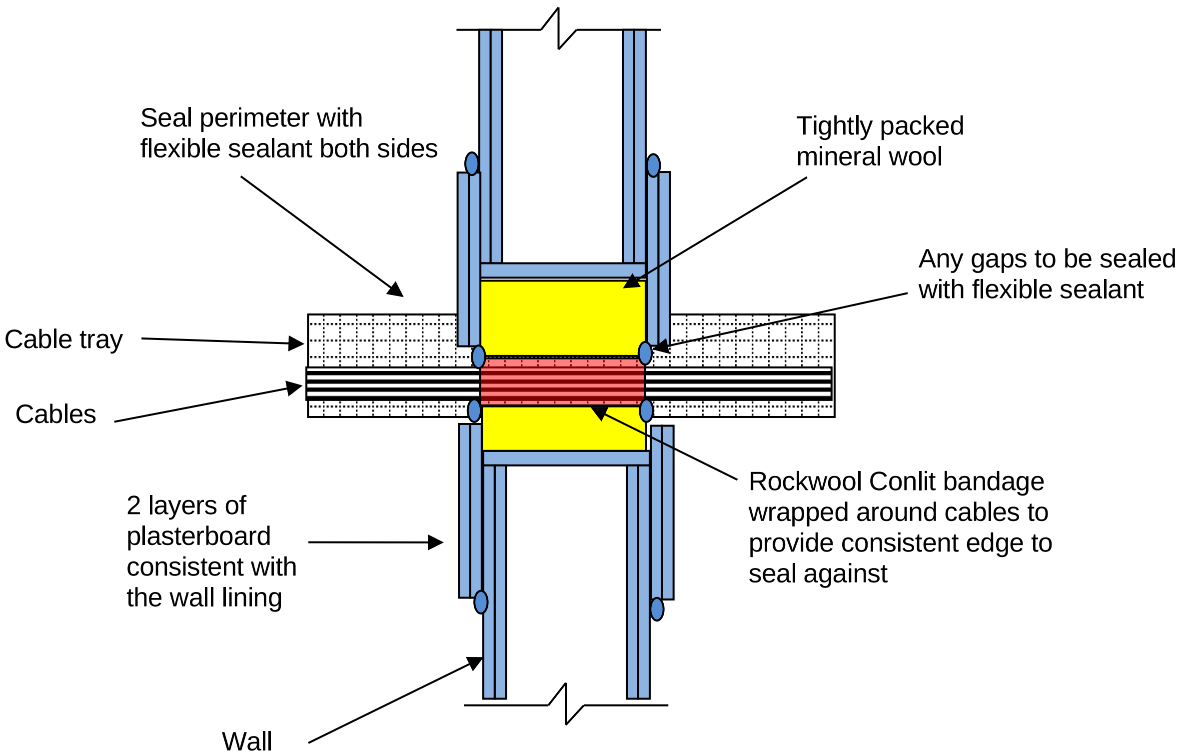
Duct Penetrations



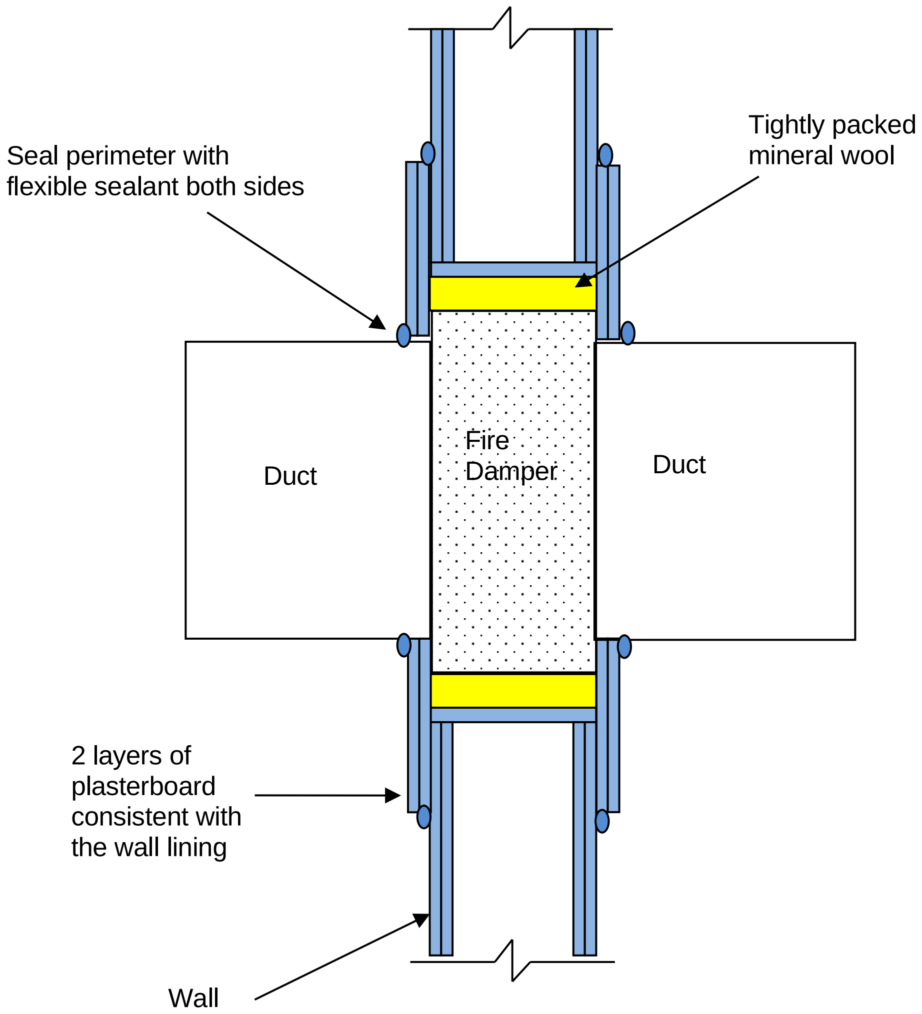
Pipe Penetrations



Cable Tray Penetrations



Fire Damper Penetrations



PART 3 – MEP SERVICES NOISE AND VIBRATION CONTROL SPECIFICATION

1.0 General

1.1 The Contractor shall include for all items of specialist noise and vibration control equipment as described in this section of the specification as necessary to achieve the noise criteria stated in part 1 section 2.2 of this specification.

1.2 Unless otherwise stated, the noise levels detailed above shall be achieved at a position 1.5 m above floor level and 1.5 m from any air grille, diffuser or register, or beneath any item of plant located within a ceiling void or at roof level. Measurements shall be made with internal areas fitted out in a functional state, and all mechanical services systems shall be running in a fully balanced condition, with constant air volume systems operating at design volume and variable air volume systems operating at not less than 80% of maximum volume.

1.3 All measurements made to show compliance with this specification shall be performed using a sound level meter conforming to class 1 of BS EN 61672-1:2003. Where there is an NR criteria single octave measurements shall be made at octave band centre frequencies from 63 Hz to 8 kHz.

1.4 The NR values scheduled are to be taken as a maximum noise level in all cases, and any tolerance above these levels will be solely at the discretion of the Acoustic Consultant dependant upon the overall characteristics of the sound spectrum concerned.

1.5 Balance of air conditioning systems shall be achieved in a progressive manner using all system dampers available, and where necessary fan pulley changes shall be implemented rather than excessive throttling of balancing dampers. Opposed blade terminal dampers must only be used to trim airflow between terminals on a common branch and must not be relied upon as a primary balancing device - the Contractor shall therefore allow adequate provision of duct mounted balancing dampers.

1.6 External Noise Emission Criteria

1.6.1 External noise emission levels due to mechanical services systems shall not exceed the following;

Noise Sensitive Receiver Location[1]	Planning BS 4142:2014 Rating Limit at 1m from Noise Sensitive Premises	
	Daytime (07:00 – 23:00)	Night Time (23:00 – 07:00)
North of the site: Closest dwelling on Hales Park	43 dB $L_{Ar,Tr}$	38 dB $L_{Ar,Tr}$
South of the site: Closest dwelling on the corner of Kingcup Avenue and Groundsel Walk	43 dB $L_{Ar,Tr}$	38 dB $L_{Ar,Tr}$

2.0 Attenuators

2.1 General

2.1.1 Attenuators shall be provided where indicated on the drawings and/or schedules to the type and details as shown therein.

2.1.2 Attenuators may be of rectangular, circular, elbow, plenum form or acoustic louvre type or whatever form is indicated.

2.1.3 Attenuators shall be delivered to site with blocked ends to prevent ingress of rubble etc. whilst stored on site, and to reduce the risk of damage. The direction of airflow through the silencer shall be clearly marked on the casing.

2.2 Acoustic Performance

2.2.1 Each attenuator shall provide insertion losses under operating conditions of not less than that indicated on the relevant schedule. The Contractor shall provide the insertion losses expected from the attenuators offered, under operating conditions.

2.2.2 The attenuator insertion losses and self-generated noise levels shall be determined in a duct to reverberant room test facility which provides for airflow through the attenuators. The test procedure shall be in accordance with BS EN ISO 7235:1996 (or equivalent), and this procedure shall be modified to allow for airflow through the attenuator, and data shall be reported in eight octave bands from 63 to 8000 Hz. The contractor shall provide such certified data as applies to the attenuator under operating conditions.

2.3 Aerodynamic Performance

2.3.1 Each attenuator shall have a pressure loss at the design gas flow and temperature of not greater than that shown in the schedules. The quoted pressure losses shall be derived from tests carried out in accordance with BS EN ISO 7235:1996 (or equivalent). Where the attenuator location is known, the expected effect of turbulence due to adjacent duct elements on the quoted pressure losses shall be included, and shown separately.

2.4 Construction

2.4.1 The attenuators shall comprise an all steel construction suitable for use in low and high velocity systems, and shall not fail structurally when subject to a differential pressure across the casing of 2000 Pa. Unless otherwise indicated in this specification or in the schedules, the casing of all attenuators shall conform to the high pressure requirements of HVCA Specification DW 144, in terms of thickness, seams, materials and leakage performance. (Small attenuators on the downstream side of items such as terminal boxes, fan coil units or similar may conform to the medium pressure requirements of DW 144).

2.4.2 Rectangular attenuators shall have an outer casing of not less than 0.7 mm thick galvanised sheet steel. Longitudinal joints shall be lock formed and mastic sealed during construction. Snap lock seams shall not be permitted on any attenuator.

2.4.3 Where acoustic elements form splitters within the attenuator, the arrangement will usually be with the splitters vertical and with a half-width splitter fixed to each side wall of the casing. However, the Contractor shall ensure that the parallel splitter elements in the silencer are correctly orientated for the adjacent duct geometry, particularly when attenuators are located near bends, bifurcations or similar details. Where horizontal splitters are needed, these should be suitably stiffened to prevent flexing and restriction of the airways.

2.4.4 The silencer splitters shall be constructed from not less than 0.6 mm perforated galvanised steel sheet, and shall be die formed single piece construction with rounded noses at each end to provide optimum aerodynamic performance (except in silencers of length less than 900 mm). The splitters shall be locked into parallel splitter tracks and be retained by spot welding to the casing at each end.

2.4.5 The splitter facings shall be suitable for air velocities up to 40 m/s without egress of fibres into the gas stream. The Contractor shall also note any particular requirements, e.g. painting, special materials etc., as may be indicated in the schedules or on drawings.

2.4.6 The splitter infill shall be inert, rot and vermin proof, non-hygroscopic medium of a density sufficient to achieve the stated acoustic performance, and packed under at least 5% compression so as to eliminate voids due to settling.

2.4.7 In the case of circular silencers, all internal acoustic elements shall generally be as described above, except as follows:

a) The outer casing shall be constructed from not less than 1.2 mm galvanised sheet steel. Longitudinal joints shall be lapped spot welded and mastic sealed, and end joints shall be lock formed and mastic sealed. The outer case will be stiffened by swaging ribs around the casing perimeter.

b) The centre pod (if any) shall be constructed from not less than 0.7 mm galvanised perforated sheet steel with not less than 1.2 mm galvanised sheet steel end plates. The inlet end will be fitted with a hemispherical dome providing a bell mouth entry to minimise turbulence.

c) The end rings shall be constructed from not less than 1.6 mm galvanised sheet steel and fitted with equally spaced drilled and tapped bushes.

2.5 Attenuator Performance Requirements

Ref.	System	Size (mm)			Air Volume (m^3/s)	Pressure Loss (Pa)
		W	H	L		
ATT AHU/S4-6/1-01	Suite AHU S04/05/06-1 Atmosphere side supply intake	1500	1500	1500	6.96	34
ATT AHU/S4-6/1-02	Suite AHU S04/05/06-1 Atmosphere side exhaust outlet	1200	1200	1500	5.84	24
ATT AHU/S4-6/1-03	Suite AHU S04/05/06-1 Room side extract inlet	1500	1500	1500	5.84	25
ATT AHU/S4-6/1-04	Suite AHU S04/05/06-1 Room side supply discharge	1500	1500	1500	6.96	34
ATT AHU/S4-6/2-01	Suite AHU S04/05/06-2 Atmosphere side supply intake	1500	1500	1500	6.96	34
ATT AHU/S4-6/2-02	Suite AHU S04/05/06-2 Atmosphere side exhaust outlet	1200	1200	1500	5.84	24
ATT AHU/S4-6/2-03	Suite AHU S04/05/06-2 Room side extract inlet	1500	1500	1500	5.84	25
ATT AHU/S4-6/2-04	Suite AHU S04/05/06-2 Room side supply discharge	1500	1500	1500	6.96	34
ATT AHU/NC1-3/1-01	Spine AHU NC01/02/03-01 Atmosphere side supply intake	700	700	1200	1.33	27
ATT AHU/NC1-3/1-02	Spine AHU NC01/02/03-01 Atmosphere side exhaust outlet	600	600	1200	0.94	26
ATT AHU/NC1-3/1-03	Spine AHU NC01/02/03-01 Room side extract inlet	600	600	900	0.94	26
ATT AHU/NC1-3/1-04	Spine AHU NC01/02/03-01 Room side supply discharge	700	700	1500	1.33	27
ATT HRU-LD01-01	Loading Dock HRU LD01-01 Atmosphere side supply intake	500	500	1200	0.69	28
ATT HRU-LD01-02	Loading Dock HRU LD01-01 Atmosphere side exhaust outlet	500	500	1200	0.69	28
ATT HRU-LD01-03	Loading Dock HRU LD01-01 Room side extract inlet	500	500	1200	0.69	28
ATT HRU-LD01-04	Loading Dock HRU LD01-01	500	500	1200	0.69	28

Ref.	System	Size (mm)			Air Volume (m^3/s)	Pressure Loss (Pa)
		W	H	L		
	Room side supply discharge					
ATT HRU-SP3-01	Spine HRU SP03-01 Atmosphere side supply intake	300	300	1200	0.014	1
ATT HRU-SP3-02	Spine HRU SP03-01 Atmosphere side exhaust outlet	300	300	1200	0.014	1
ATT HRU-SP3-03	Spine HRU SP03-01 Room side extract inlet	300	300	1200	0.014	1
ATT HRU-SP3-04	Spine HRU SP03-01 Room side supply discharge	300	300	1200	0.014	1
ATT HRU-SP4-01	Spine HRU SP04-01 Atmosphere side supply intake	300	300	1200	0.014	1
ATT HRU-SP4-02	Spine HRU SP04-01 Atmosphere side exhaust outlet	300	300	1200	0.014	1
ATT HRU-SP4-03	Spine HRU SP04-01 Room side extract inlet	300	300	1200	0.014	1
ATT HRU-SP4-04	Spine HRU SP04-01 Room side supply discharge	300	300	1200	0.014	1
ATT EF-HBR03-01	Extract Fan HBR03-01 Room side extract inlet	300	300	600	0.014	1
ATT EF-HBR03-02	Extract Fan HBR03-01 Atmosphere side exhaust outlet	300	300	600	0.014	1
ATT EF-HBR04-01	Extract Fan HBR04-01 Room side extract inlet	300	300	600	0.014	1
ATT EF-HBR04-02	Extract Fan HBR04-01 Atmosphere side exhaust outlet	300	300	600	0.014	1

Ref.	octave band centre frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
	insertion loss (dB)							
ATT AHU/S4-6/1-01	7	14	24	39	45	46	42	31
ATT AHU/S4-6/1-02	5	10	18	29	35	33	22	15
ATT AHU/S4-6/1-03	7	14	24	39	45	46	42	31
ATT AHU/S4-6/1-04	7	14	24	39	45	46	42	31
ATT AHU/S4-6/2-01	7	14	24	39	45	46	42	31
ATT AHU/S4-6/2-02	5	10	18	29	35	33	22	15
ATT AHU/S4-6/2-03	7	14	24	39	45	46	42	31
ATT AHU/S4-6/2-04	7	14	24	39	45	46	42	31
ATT AHU/NC1-3/1-01	6	11	19	32	38	39	34	27
ATT AHU/NC1-3/1-02	6	11	19	32	38	39	34	27
ATT AHU/NC1-3/1-03	4	9	15	24	33	33	28	21
ATT AHU/NC1-3/1-04	7	14	24	39	45	46	42	31
ATT HRU-LD01-01	6	11	19	32	38	39	34	27
ATT HRU-LD01-02	6	11	19	32	38	39	34	27
ATT HRU-LD01-03	6	11	19	32	38	39	34	27
ATT HRU-LD01-04	6	11	19	32	38	39	34	27
ATT HRU-SP3-01	4	8	15	22	28	27	18	12
ATT HRU-SP3-02	4	8	15	22	28	27	18	12
ATT HRU-SP3-03	4	8	15	22	28	27	18	12
ATT HRU-SP3-04	4	8	15	22	28	27	18	12
ATT HRU-SP4-01	4	8	15	22	28	27	18	12
ATT HRU-SP4-02	4	8	15	22	28	27	18	12
ATT HRU-SP4-03	4	8	15	22	28	27	18	12
ATT HRU-SP4-04	4	8	15	22	28	27	18	12

Ref.	octave band centre frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
	insertion loss (dB)							
ATT EF-HBR03-01	2	5	9	13	14	14	10	8
ATT EF-HBR03-02	2	5	9	13	14	14	10	8
ATT EF-HBR04-01	2	5	9	13	14	14	10	8
ATT EF-HBR04-02	2	5	9	13	14	14	10	8

N.B: All attenuator selections are based upon PPA Tender stage equipment selections and are as such indicative only, pending final contractor plant selections.

3.0 Fan Coil Units

3.1 Fan coil units shall be selected so as not to exceed the roomside noise criteria shown below. These sound criteria must be achieved under worst case operating conditions (not necessarily maximum airflow). Certified laboratory test data for measurements carried out in accordance with BS 4856:Part 4:1997 shall be presented as proof of compliance..

3.2 The fan and motor assembly shall be resiliently isolated such that vibration transmission into the building structure and/or resonances within the unit casing do not cause the specified limits to be exceeded. The whole shall be so designed such that no special vibration isolation precautions are required in either the unit suspension system or any connecting ductwork.

3.3 Any fan motor speed control equipment shall be considered as part of the whole box assembly, and any transformer or control gear electrical noise shall be sufficiently attenuated within the limits specified.

3.4 Any inlet or discharge attenuators required in order to achieve these sound power level limits shall be constructed as detailed elsewhere in the specification.

3.5 The maximum noise levels to be achieved are as follows:

Plant	Limiting Internal Noise Criterion
Flexible Space FCUs	NR 35
V/C Enabled Flexible Space FCUs	NR 32

3.6 The above noise criteria take into account the combined noise from all FCUs present within each space

3.7 All contractor Fan Coil Unit selections must be forwarded to Applied Acoustic Design for comment.

4.0 Packaged Generators

4.1 Packaged generators shall have noise levels not exceeding 60 dB L_{pA} at 1 m when measured free-field over a reflecting plane at any point around all sides of the unit, including at 1m from the generator flue. In addition, the octave band sound pressure levels achieved at 1 m shall not exceed the following at any point around the unit;

	octave band centre frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8K	
	sound pressure level, dB re $2x10^{-5}$ Pa								
Generator - Lp at 1 m	48	63	60	56	53	51	47	51	60
Generator Flue - Lp at 1 m	35	35	55	52	52	54	53	49	60

4.2 Factory tests shall be performed prior to delivery to demonstrate compliance with this specification. Sound pressure levels shall be obtained using a properly calibrated sound level meter conforming to Type 1 of BS EN 600651:1994 or Class 1 of BS EN 61672-2:2013+A1:2017. The maximum tolerance on the achieved measurements shall be + 0 dBA overall, and +3 dB in any octave band (provided that the overall dBA value is achieved). Manufacturers shall note this requirement, and allow for any operating margin to ensure that this specification is achieved.

4.3 The noise levels specified shall be achieved under worst case operating conditions (not necessarily maximum airflow). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

4.4 Vibration Isolation

4.4.1 The generator and any associated housing must be supported on appropriate vibration isolation bearings. See Section 11.3.4 below for indicative vibration isolation specifications, to be confirmed by the generator manufacturer.

5.0 Chillers

5.1 Option 1

5.1.1 The sound power levels of each chiller, including the influence of any necessary attenuation package, must not exceed the following limits. The limits presented below should be met in any unit location/configuration.

Plant	octave band centre frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8K	
	sound power level, dB re 10^{-12} W								
Data Centre Chillers	90	86	88	86	82	76	66	58	87
E Pod Chillers	83	79	81	79	75	69	59	51	80

5.1.2 Tests should be undertaken to demonstrate compliance with these noise level limits, in the presence of the Acoustic Consultant in a properly approved test facility. The tests shall be undertaken in accordance with BS EN ISO 9614-1:2009 (sound intensity) or BS EN ISO 3744:2010 (engineering method – sound pressure).

5.1.3 The maximum tolerance applicable to the measurements shall be no more than the limits applicable to Type 1 or Class 1 measurement equipment as defined in BS EN 60651:1994 and BS EN 61672-2:2013+A1:2017.

5.1.4 The chiller under test shall be set to the worst-case noise level operating condition (not necessarily under maximum load). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

5.1.5 As the units are proposed to be raised above ground level, the chiller supplier must demonstrate that noise radiating from the underside of the unit does not give rise to an exceedance of these criteria.

5.2 Option 2

5.2.1 Chillers shall have noise levels not exceeding 54 dB L_{pA} at 10 m when measured free-field over a reflecting plane in the raised configuration as shown in the building services consultant's drawings, at any point around all four sides of the unit. In addition, the octave band sound pressure levels achieved at 10 m shall not exceed the following at any point around the unit;

	octave band centre frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8K	
	sound pressure level, dB re $2x10^{-5}$ Pa								
Data Centre Chillers - Lp at 10 m	57	53	55	53	48	42	33	25	54
E Pod Chillers - Lp at 10 m	50	46	48	46	41	35	26	18	47

5.2.2 Factory tests shall be performed prior to delivery to demonstrate compliance with this specification. Sound pressure levels shall be obtained using a properly calibrated sound level meter conforming to Type 1 of BS EN 600651:1994 or Class 1 of BS EN 61672-2:2013+A1:2017. The maximum tolerance on the achieved measurements shall be + 0 dBA overall, and +3 dB in any octave band (provided that the overall dBA value is achieved). Manufacturers shall note this requirement, and allow for any operating margin to ensure that this specification is achieved.

5.2.3 The noise levels specified shall be achieved under worst case operating conditions (not necessarily maximum airflow). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

6.0 Cooling Units

6.1 The sound power levels of each cooling must not exceed the following limits. The limits presented below should be met in any unit location/configuration.

Plant	octave band centre frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8K	
	sound power level, dB re 10^{-12} W								
Suite Cooling Units - Intake	69	73	76	73	74	72	69	64	79
Suite Cooling Units - Discharge	64	68	71	68	69	67	64	59	74
Spine Cooling Units	60	64	67	64	65	62	59	55	70
E Pod Cooling Units	68	72	75	72	73	71	68	63	78

6.2 Tests should be undertaken to demonstrate compliance with these noise level limits, in the presence of the Acoustic Consultant in a properly approved test facility. The tests shall be undertaken in accordance with BS EN ISO 9614-1:2009 (sound intensity) or BS EN ISO 3744:2010 (engineering method – sound pressure).

6.3 The maximum tolerance applicable to the measurements shall be no more than the limits applicable to Type 1 or Class 1 measurement equipment as defined in BS EN 60651:1994 and BS EN 61672-2:2013+A1:2017.

6.4 The unit under test shall be set to the worst-case noise level operating condition (not necessarily under maximum load). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

7.0 Chiller Yard Condensers

7.1 The sound power levels of chiller yard condensers must not exceed the following limits. The limits presented below should be met in any unit location/configuration.

Plant	Limiting Sound Power Level L_{wA}
Chiller Yard Condensers	75 dB

7.2 Tests should be undertaken to demonstrate compliance with these noise level limits, in a properly approved test facility. The tests shall be undertaken in accordance with BS EN ISO 9614-1:2009 (sound intensity) or BS EN ISO 3744:2010 (engineering method – sound pressure).

7.3 The maximum tolerance applicable to the measurements shall be no more than the limits applicable to Type 1 or Class 1 measurement equipment as defined in BS EN 60651:1994 and BS EN 61672-2:2013+A1:2017.

7.4 The unit under test shall be set to the worst-case noise level operating condition (not necessarily under maximum load). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

8.0 Pumps

8.1 The sound power levels of pumps and pump room must not exceed the following limits. The limits presented below should be met in any unit location/configuration.

Plant	Limiting Sound Power Level L_{wA}
E Pod Pumps	60 dB
Data Centre Chiller Pump Rooms	75 dB

8.2 Tests should be undertaken to demonstrate compliance with these noise level limits, in a properly approved test facility. The tests shall be undertaken in accordance with BS EN ISO 9614-1:2009 (sound intensity) or BS EN ISO 3744:2010 (engineering method – sound pressure).

8.3 The maximum tolerance applicable to the measurements shall be no more than the limits applicable to Type 1 or Class 1 measurement equipment as defined in BS EN 60651:1994 and BS EN 61672-2:2013+A1:2017.

8.4 The unit under test shall be set to the worst-case noise level operating condition (not necessarily under maximum load). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

9.0 Transformers

9.1 Transformers shall have noise levels not exceeding 70 dB L_{pA} at 2 m when measured free-field on a reflective ground at any point around the unit.

9.2 Factory tests shall be performed prior to delivery to demonstrate compliance with this specification. Sound pressure levels shall be obtained using a properly calibrated sound level meter conforming to Type 1 of BS EN 600651:1994 or Class 1 of BS EN 61672-2:2013+A1:2017. The maximum tolerance on the achieved measurements shall be + 0 dBA overall. Manufacturers shall note this requirement, and allow for any operating margin to ensure that this specification is achieved.

9.3 The noise levels specified shall be achieved under worst case operating conditions (not necessarily maximum airflow). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

10.0 Small Extract Fans

10.1 Toilet and Cleaners' Store extract systems must comply with the sound pressure level limits presented below.

Plant	**Limiting Sound Pressure Level L_{Aeq}, NR**
Toilet Extract Fans - Inlet	NR 40
Toilet Extract Fans - Outlet	40 dB L_{Aeq} at 1m
Cleaners Store Extract Fans - Inlet	NR 45
Cleaners Store Extract Fans - Outlet	40 dB L_{Aeq} at 1m

10.2 Manufacturer's test data shall be provided to demonstrate compliance with the above criteria. Sound pressure levels shall be obtained using a properly calibrated sound level meter conforming to Type 1 of BS EN 600651:1994 or Class 1 of BS EN 61672-2:2013+A1:2017. The maximum tolerance on the achieved measurements shall be + 0 dBA overall. Manufacturers shall note this requirement, and allow for any operating margin to ensure that this specification is achieved.

10.3 The noise levels specified shall be achieved under worst case operating conditions (not necessarily maximum airflow). Any fan motor speed control equipment shall be considered as part of the whole assembly, and any transformer, control gear or inverter electrical noise shall be sufficiently attenuated within the limits specified and shall not exhibit any pronounced tonal components.

11.0 Vibration Isolation

11.1 Introduction

11.1.1 All rotating elements encompassed within the description Building Services Plant and Equipment are to be adequately protected against excessive transmission of residual vibration to the supporting local structure.

11.2 Balance

11.2.1 All rotating elements covered by this specification shall be statically and dynamically balanced prior to installation or prior to commissioning the duty of the plant. Certification must be made available upon request to confirm that balance has been achieved such that the maximum residual unbalance (RMS velocity mm/sec, 1 Hz to 80 Hz bandwidth) is in accordance with the values stated as follows, for maximum service speed;

Equipment	RMS Velocity (1Hz – 80 Hz) mm/sec
Turbines, turbo-compressors, turbine driven pumps	2.5
Electric motor driven machines, inc. fans and pumps	6.3
Electric motor driven reciprocating machines	40.0
Fast 4 cycle engines (over 9m/s piston speed), gasoline or diesel	100.0

11.2.2 Any plant or equipment falling outside of the above descriptions must be notified by the Contractor to the Acoustic Consultant in writing, who will respond in writing with the balance quality grade required.

11.2.3 This specification and attendant schedules state the specialist vibration control equipment performance required and the type of isolating mechanism necessary to achieve it. Selection of such devices with regard to loads sustained, installation techniques and environmental conditions affecting selection, including temperature and pressure, must also be considered by the Contractor. To assist this procedure, the Contractors attention is drawn to the guidelines as laid down in ISO 2017-1982 "Vibration and shock isolators - procedure for specifying characteristics", which serves as a guide for the exchange of technical information between the Contractor (for the purposes of this specification) and the supplier of vibration control equipment.

11.2.4 The above standards, together with the schedules for specialist vibration control hardware and their attendant careful selection and installation by the Contractor, are specified in order to ensure that residual building vibration is maintained within the limits as indicated by Curve 4 of BS 6472:1984 "Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)". Upon any occasion whereby the equipment balance quality grades are proven and accepted, with all specified vibration control hardware installed to the satisfaction of the Acoustic Consultant, but excessive transmission of residual vibration to the structure occurs, the Contractor will be deemed to have discharged his responsibilities under this part of the specification.

11.3 Vibration Control Equipment

11.3.1 Vibration control equipment shall be as specified in the schedules for all Building Services equipment. It must be noted that vibration isolators neither reduce amplitude nor frequency of the source vibration but reduce the magnitude of the energy transmission.

11.3.2 With regard to engineering practicality, the following energy absorbing materials are specifically not acceptable unless the contrary is confirmed in special cases in writing:

Material	Reason
Natural Rubber	Damaged by oil and (unconfigured) other hydrocarbons
Felt	Highly fluid absorbing
Natural Cork (un-agglomerated)	Poor mechanical integrity, and hygroscopic

11.3.3 The Building Services plant and equipment schedules indicate against each item of plant, a relevant specification reference for vibration control equipment. Unless otherwise stated, services pipe and ductwork systems shall be isolated for a distance of not less than 15m from the host plant by isolators having no less efficiency than that for the host plant at source. Structural penetration details will be required to ensure this in a number of cases.

11.3.4 Specific vibration isolation requirements to be as per the following schedule (to be confirmed by contractor when unit selections are finalized);

Plant	Location	Mount Spec.	Static Deflection (mm)	Base Spec.	Notes
Condenser units	Various	B	15	-	
AHU (fan unit)	Various	C	25	J	To fan within AHU
AHU (unit)	Various	A	5	-	Beneath base frame
Pumps	Various	C/G	20	J/L	Spec P connections, acoustically lagged
Extract Fans	Various	F/G/H	25	-	Spec P connections
HRUs	Various	F/G/H	25	-	Spec P connections
Chillers	Various	C	50	J	Spec M & P
Cooling Units	Various	A	25	-	-
Generator	Various	C/E	50	J/K	Spec N, M & P connections

N.B. Information shown is preliminary, pending actual plant selections.

11.3.5 Individual reference specifications are shown in the following section.

SPECIFICATION A

Mat and Pad Mountings

A.1 Mat and pad mountings shall comprise configured synthetic rubber (or elastomer such as neoprene) in compression between two rigid and flat surfaces.

A.2 Mat and pad mounts shall be cut to the appropriate size to provide the specified minimum static deflection, however, no pad shall be smaller than 50mm x 50mm x 5 mm. The mat and pad mountings may be stacked to increase unit deflection but overall stacked and loaded height must not exceed 40 mm. When stacking, 18 swg steel sheet shall be bonded between each pad without filling voids. Where the above dimensions become impractical, the installed aspect ratio of width to height shall be 0.80 or less.

A.3 Contractors must confirm that final vibration control equipment selections meet with the specification contained herein and that the effects due to creep and bulk compression are not significant for mat and pad mountings selected. Contractors must ensure that mat and pad mountings are not employed where ambient or equipment frame temperatures exceed 70^{o}C unless manufacturers certificates of high temperature worthiness are produced to the Acoustic Consultant for approval.

SPECIFICATION B

Turret Compression Mountings

B.1 Turret Compression Mountings shall comprise a synthetic rubber (or elastomer such as neoprene) turret in compression between two steel plates with complete lateral freedom for deformation. All metal surfaces must be covered to avoid corrosion and have friction pads both top and bottom. Bolt holes shall be provided in the top and bottom plates to facilitate fixing.

B.2 Compression-type mountings are to be used in preference to tension and sheer type mountings due to their greater load capacity and mechanical reliability.

B.3 Contractors must confirm that final vibration control equipment selections meet with the specifications contained herein and that the effects due to creep and bulk-compression are not significant for units selected. Contractors must ensure that turret compression mountings are not employed where ambient or equipment frame temperatures exceed 70^{o}C unless manufacturer certificates of high temperature worthiness are produced to the Acoustic Consultant for approval.

SPECIFICATION C

Helical Steel Spring Compression Mountings

C.1 Helical Steel Spring Compression Mountings shall comprise single or multiple spring elements, shall be free standing and laterally stable, and shall be provided with a synthetic rubber or elastomeric friction pad to the baseplate. All springs shall have coil diameters of not less than 0.80 of the compressed height at the rated load to ensure stability.

C.2 All mountings shall have levelling bolts that must be rigidly bolted to the equipment. There shall be provision for bolting through the base plate in at least two places.

C.3 Mountings shall have at least 25% and preferably 50% of rated static deflection additional travel to solid to cater for plant and equipment weight and superimposed load variations and inaccuracies.

SPECIFICATION D

Vertically Restrained Helical Steel Spring Compression Mountings

D.1 Vertically restrained helical steel spring compression mountings shall be used in cases where equipment has an operating weight different from the installed weight, and where equipment is exposed to wind loading.

D.2 Mountings shall be as described under Specification C, but a mechanism shall be provided that includes an adjustable vertical limit stop to prevent spring extension when load is decreased. A minimum clearance of 5 mm shall be maintained around restraining bolts and the limit stop plate so as not to interfere with the spring action. Limit stops shall be adjusted to be not more than 5 mm out of contact during normal operation.

D.3 Mountings used in the external environment shall exhibit an additional deflection capacity and restraint mechanism capable to accepting the rated load plus 150 kg/m^2 of equipment face area (ratio seen at each mount). The largest face area shall be employed in calculations.

D.4 Mountings used in the external environment must be adequately protected against environmental and atmospheric degradation.

SPECIFICATION E

Horizontally Restrained Helical Steel Spring Mountings

E.1 Horizontally restrained helical steel spring mountings shall be used in cases where equipment regularly cycles on and off and in cases where horizontal periodic loads may occur.

E.2 Horizontal restraints shall be incorporated into the design of the mounting and shall be such that when in contact with the spring coupled element, complete shorting out shall not be possible. Synthetic rubber of elastomer inserts having adequate compressive strength shall be used to provide a horizontal buffer to limit excessive movement. Snubbers shall be out of contact during normal operation. Mountings shall be as described under Specification C.

SPECIFICATION F

Hanger Turret Compression Mountings

F.1 Hanger turret compression mountings shall comprise turret compression mountings generally in accordance with Specification B, incorporated within a steel hanger box.

F.2 The hanger box shall be constructed from at least 16 swg steel and have construction with mechanical strength commensurate with design loads. Boxes shall have an upper fixing hole and an enlarged bottom hole through which the drop rod contacts the supported plant or equipment. The lower box hole diameter shall be adequately size to provide free drop rod movement up to 15^{o} free vertical in any direction in order to compensate for thermal and other movement of supported equipment.

SPECIFICATION G

Hanger Helical Steel Spring Compression Mountings

G.1 Hanger helical steel spring compression mountings shall comprise helical steel springs from mountings generally in accordance with Specification C incorporated within a steel hanger box, with synthetic rubber elastomer being at least one end of the spring.

G.2 The hanger box shall be constructed from at least 16 swg steel and have construction with mechanical strength commensurate with design loads. Boxes shall have an upper fixing hole and an enlarged bottom hole through which the drop rods contacts the supported plant to equipment. The lower box hole diameter shall be adequately sized to provide free drop rod movement up to 15^{o} from vertical in any direction in order to compensate for thermal and other movement of supported equipment.

SPECIFICATION H

Combination Hanger Turret/Helical Steel Spring Compression Mountings

H.1 Combination hanger turret/helical steel spring compression mountings shall comprise Specification G hanger with enlarged hanger box able to incorporate a turret synthetic rubber or elastomer turret mounting at the top of the box.

SPECIFICATION J

Steel Equipment Bases

J.1 Steel frame equipment bases shall be made sufficiently rigid to enable permanent equipment alignment and support, and adequately stiff to prevent resonances at operating frequencies of supported equipment.

J.2 Perimeter steel beams shall have a depth of not less than 1/10 the longest dimension of the base and not greater than 350 mm. Cross framing should be used to provide adequate strength and stiffness.

SPECIFICATION K

Concrete Equipment Bases

K.1 Concrete equipment bases shall comprise a reinforced steel concrete base of depth not less than 150 mm case in situ over 16 swg steel sheet of identical plan dimensions. This construction, which is to accept the equipment weight bolted to directly to it, is to be placed on a layer of Specification A material of nominal thickness 20 mm, which is itself placed over a concrete upstand base of depth not less than 100 mm, cast into the structural floor.

SPECIFICATION L

Concrete Inertia Bases

L.1 Concrete inertia bases shall be formed from steel beam shuttering with perimeter beams having a depth of not less than 1/12 the largest dimension of the base of 150 mm (whichever is the greater), and no greater than 300 mm. The bottom of the frame shall be blanked off, and concrete (min. 2300 kg/m^3) poured in over steel reinforcing. This reinforcing should consist of 13 mm diameter bars welded on 150 mm centres running cross-batch in a layer 35 mm above the bottom of the base and no greater than 300 mm, or as specified by the Structural Engineer.

L.2 The inertia base shall be sufficiently large to provide support for all parts of the equipment base, such as suction and discharge elbows on centrifugal pumps. Unless otherwise specified in the schedules, the weight of the base shall be twice that of the supported equipment, and the included angle between the mounting positions and overall centre of gravity should be no less than 60^o.

L.3 Alternative constructions should be passed to the Structural Engineer for approval.

SPECIFICATION M

Flexible Hose Pipe Couplings

M.1 Water serviced plant isolated by vibration control equipment must be equipped with flexible hose pipe couplings which are able to flex and thereby maintain de-coupling from the structure and minimise stress to pipework.

M.2 Flexible hose pipe couplings must be installed to flex transversely since they are quite stiff axially, thus flexible pipe couplings must be installed horizontally and parallel to the rotating shafts of the plant.

M.3 The rods and control cables may be fitted to prevent excessive elongation and these must be out of rigid contact or slack during normal operation.

M.4 Contractors must ensure that the flexible hose couplings submitted are capable of withstanding fluid temperatures and pressures expected in the system.

SPECIFICATION N

Pipe Wall and Riser Seal

N.1 Where piped services associated with rotating machinery such as pumps or refrigeration machines pass through plantroom floors and walls, they shall in all cases be enclosed concentrically within purpose made sleeves, cut square from steel pipe three sizes larger, and three penetration thicknesses in length.

N.2 Sleeves shall be grouted into the wall/floor and in no case be used as pipe supports, a free annular space always being provided. The space between sleeve and pipe shall then be sealed by packing with mineral wool or glass fibre sleeve for the depth of the wall/floor minus 12 mm.

N.3 A 12 mm thick non-hardening cold mastic seal shall then be applied to both ends of the packing to bring the joint level with the sleeve end.

SPECIFICATION P

Ductwork Flexible Connection

P.1 Where ductwork flexible connections are required they shall be manufactured from high grade woven fire-resisting cloth with an impermeable coating applied by vacuum diffusion, and a nominal superficial weight in the range 1 to 10 kg/m^2 suitable for the application.

P.2 A minimum distance of 25 mm shall be allowed between faces to be bridged by the flexible connection.

P.3 The connection shall be made by clamping the entire perimeter of both ends of the flexible element, the minimum length of which shall be 250 mm so as to ensure excess material allows for relative motion to arise without being arrested by tension in the connection.

P.4 The flexible connection shall be installed in such a way as to avoid impeding air flow.

EUROPEAN OFFICES

United Kingdom

AYLESBURY
T: +44 (0)1844 337380

BELFAST
belfast@slrconsulting.com

BRADFORD-ON-AVON
T: +44 (0)1225 309400

BRISTOL
T: +44 (0)117 906 4280

CARDIFF
T: +44 (0)29 2049 1010

CHELMSFORD
T: +44 (0)1245 392170

EDINBURGH
T: +44 (0)131 335 6830

EXETER
T: + 44 (0)1392 490152

GLASGOW
T: +44 (0)141 353 5037

GUILDFORD
T: +44 (0)1483 889800

LONDON
T: +44 (0)203 805 6418

MAIDSTONE
T: +44 (0)1622 609242

MANCHESTER
T: +44 (0)161 872 7564

NEWCASTLE UPON TYNE
T: +44 (0)191 261 1966

NOTTINGHAM
T: +44 (0)115 964 7280

SHEFFIELD
T: +44 (0)114 245 5153

SHREWSBURY
T: +44 (0)1743 23 9250

STIRLING
T: +44 (0)1786 239900

WORCESTER
T: +44 (0)1905 751310

Ireland

DUBLIN
T: + 353 (0)1 296 4667

France

GRENOBLE
T: +33 (0)6 23 37 14 14