Cole Jarman

44 Saffron Hill

# Plant Noise Assessment

Report 17/0414/R1

44 Saffron Hill

# Plant Noise Assessment

Report 17/0414/R1

E&A (Saffron Hill) Limited

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London
EC1N 6TD

| Revision | Description | Date | Prepared | Approved |
|---|---|---|---|---|
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# Plant Noise Assessment

## 1 Introduction

1.1 Planning permission is being sought for the change of use of existing lower ground and part ground floor to office use Class B1 (a), together with minor external alterations at 44 Saffron Hill, London, EC1N 8FH.

1.2 Part of this conversion includes installing 2 no. new condenser units at basement level, to be located internally.

1.3 Cole Jarman have undertaken a noise survey on site, the methodology and results of which, are published in this report. A plant noise assessment has also been undertaken, with mitigation proposed as necessary in order to meet planning noise limits.

## 2 Site Description

2.1 The site and surrounding area can be seen in attached site pan figure 17/0414/F01. The site is in the London borough of Camden.

2.2 The building is currently a mix of residential and commercial accommodation with parking at ground and basement level.

2.3 The new condenser plant is to be located at basement level on the eastern side of the building. Two new condenser units are to be installed internally, ducting out into the existing plant area which currently has five condenser units already installed, understood to serve the existing residents and commercial properties. Details of the new plant are set out in section 4.1.

2.4 The closest noise sensitive receiver to the proposed plant is the existing residential apartment at first floor level of the application building. There is an external terrace / balcony at first floor level which screens the first and upper floor windows from the proposed basement plant location.

2.5 The property directly to the east has commercial units at ground and first floor. It has been assumed the 2$^{nd}$ floor is residential. The property to the south of (southeast of the site) has a commercial unit on the ground floor and residential on the 1$^{st}$ floor, and assumed residential above.

2.6 The adjacent plot of land to the north east corner of the building has planning permission for new residential dwellings, however work has not commenced. Given the existing noise climate to that location already comprises plant noise from the other condensers, this potential development should already take account of the existing units; therefore, we do not propose to assess to this hypothetical location; the onus being on that future development to design for the 'existing' noise climate (which is already comprised of plant noise to which it is unlikely the new plant will significantly elevate).

# 3 Noise Survey

## 3.1 Methodology and Equipment

3.1.1 A noise survey was conducted to establish typical background noise levels at the nearest noise sensitive receptors to the proposed plant location. This consisted of unattended measurements from 11h00 on 22nd June to 11h00 on 23rd June 2017.

3.1.2 The timing of the survey was chosen to capture the typical noise climate during the quietest hours of the day and night. The measurement position was on a pole against the ground floor parapet next to the lightwell where the existing plant is positioned, in the southeast corner of the site. This meant the meter was 4 m above ground floor level, approximately 8 m above basement level and representative of 1st floor windows. This position is also shown in 17/0414/F01 as MP1.

3.1.3 Measurements of the $L_{Aeq}$, $L_{Amax}$ and $L_{A90}$ indices were taken over consecutive 15 minute periods (see Glossary of Acoustic Terms for an explanation of the noise units used).

3.1.4 Noise measurements were taken using the equipment listed in Table T1 below:

| Item | Manufacturer | Type |
|---|---|---|
| Sound Level Analyser | Rion | NL-52 |
| Acoustic Calibrator | Rion | NC-74 |
| Weatherproof windshield | Rion | WS-15 |

T1 Equipment used during noise survey

3.1.5 The microphone was fitted with a windshield and was calibrated before and after the survey to ensure a consistent and acceptable level of accuracy was maintained throughout.

3.1.6 The weather conditions when setting up the equipment were warm, dry and a light breeze. When picking up the equipment it was again warm and dry with a light breeze.

## 3.2 Results and Analysis

3.1 The results of the noise survey are presented in attached time history graph figure 17/0414/TH01. The noise climate was dominated by noise from the existing plant; with some contribution also from road traffic on from Saffron Hill, distant road traffic and intermittent construction noise. The effect of the existing plant can clearly be seen in the data whereby a drop in noise levels occurred at 2am.

3.2.1 The representative background noise levels, established through analysis of the measured levels in accordance with section 8 of BS4142:2014, are shown in the table below:

| Location | Representative Background Noise Level, dB | |
|---|---|---|
| | Fully Operational (0600-2100) | Setback Mode (2100-0600) |
| MP1 | 59 | 51 |

T2 Representative background noise levels at the nearest residential properties.

3.2.2 These time periods have been chosen based upon the likely operating times noted by the client, rather than the more typical 'daytime' (0700-2300) and 'night (2300-0700) periods. Although the condensers are not likely to operate over night when not required for this commercial office use, for the purpose of the assessment we have been robust and considered them operating at all times, but at a 'setback' mode as detailed in the manufactures operational handbook for the effective night time period.

## 3.3 Plant Noise Limits

3.2 The site falls within the jurisdiction of the London Borough of Camden. As part of the Camden Local Plan (Adopted June 2017), the following noise limits are proposed as part of Appendix 3: Nosie Thresholds, linked to policy A4:

*'A relevant standard or guidance document should be referenced when determining values for LOAEL and SOAEL for non-anonymous noise. Where appropriate and within the scope of the document it is expected that British Standard 4142:2014 'Methods for rating and assessing industrial and commercial sound' (BS 4142) will be used. For such cases a 'Rating Level' of 10 dB below background (15 dB if tonal components are present) should be considered as the design criterion).'*

3.3.1 Therefore, based upon this guidance of 10dB below background, plant noise levels have been set for the nearest residential receivers and can be seen in the table below:

| Location | Noise Emission Limit, dB | |
|---|---|---|
| | Fully Operational (0600-2100) | Setback Mode (2100-0600) |
| AP1 and AP2 | 49 | 41 |

T3 Plant noise emission limits at the nearest residential properties

3.3.2 Plant noise limits have been set at the two nearest residential properties. These are the most sensitive adjacent residential dwellings and so the noise limits will also be met at other nearby dwellings. The assessment positions are described here:

- AP1 – east-facing 1st floor residential window above plant pit
- AP2 – west-facing 1st floor residential window to southeast of site

# 4 Plant Noise Assessment

## 4.1 Details

4.1.1 Our assessment is based upon information and drawings provided by iceni projects. Noise data for the units were obtained from the manufacturers directly. The plant is to be located in a basement plant room, with louvered panel in the façade to provide airflow. Typically, such units draw air in through a louvre (for supply air) and the exhaust of the unit is then ducted to the façade.

4.1.2 The nearest noise sensitive receivers and their relative location to the plant are described in section 3.3.2 above. In summary they are:

- AP1: 1st floor apartment above plant
- AP2: 1st floor residence to southeast of site

4.1.3 Our assessment has taken into account distance and screening losses as appropriate. Full calculations can be seen in the attached calculation sheets 17/0414/CS1-10.

4.1.4 The proposed plant items and their associated noise levels are listed in the table below:

| Unit | Sound Power Level ($L_w$, dB) @ Octave Band Centred Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| CU1: Daikin REYQ12T | 74.5 | 81.5 | 81.0 | 80.5 | 75.5 | 70.5 | 65.5 | 61.5 |
| CU2: Daikin REYQ20T | 88.0 | 87.0 | 87.5 | 87.5 | 82.5 | 77.5 | 73.5 | 68.5 |

T4 Plant equipment noise levels

4.1.5 It can be seen that the plant is not tonal; therefore, no acoustic feature correction is necessary. In the calculation the noise from the units has been divided to account for the intake and the discharge separately, hence the differing levels used for these elements in the assessment.

4.1.6 Data obtained from Daikin on the relevant condenser units shows that the setback 'quiet noise mode' is 9 dB lower for the 12T model and 18 dB for 20T model. In both cases the reduction

is greater than the 8 dB difference between the fully operational and setback mode limits. Therefore, the more onerous criterion to meet is fully operational; if this is achieved, the setback mode limit will also be achieved.

4.1.7 It should also be noted that the condensers are only planned to be used when fully operational and the cutback mode is precautionary, as per section 3.2.2.

## 4.2 Required Mitigation Measures

4.2.1 The louvre that air is drawn into must be acoustically rated and comply with the insertion losses in the table below.

4.2.2 Exhaust air from the condensers must be ducted to terminate at the louvre. Silencers meeting the insertion losses in the table below must be placed in the appropriate duct runs.

| Unit | Insertion Loss (dB) @ Octave Band Centred Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| Acoustically rated louvre | 5 | 7 | 10 | 12 | 14 | 16 | 13 | 12 |
| CU1 – exhaust silencer | 3 | 5 | 9 | 13 | 13 | 13 | 8 | 6 |
| CU2 – exhaust silencer | 5 | 11 | 19 | 25 | 25 | 25 | 20 | 15 |

T5 Required insertion losses

4.2.3 The above silencer specifications are expected to be achievable with standard splitter silencers ranging from 600-1200mm long, with free areas of 35-50%. The silencers should be sized to avoid significant pressure drops (ideally less than 40Pa, but a mechanical engineer should be consulted).

4.2.4 The performance required of the louvre should be achievable with a unit 300mm deep. This will though likely have a free open area of approximately 25-30% and the louvre should be sized to ensure suitable levels of airflow are provided into the internal plant room.

4.2.5 In addition to the silencers and louvre, the plant room walls should also have 6m$^2$ of absorbent treatment included, ideally close to the condensers. The product selected must be suitable for the environment of a plant room and the attached specification 17/0414/SPC1 should be followed; this details a common solution of tissue faced mineral wool (50mm thick) behind open metal mesh. Alternative options or products for the absorptive lining could be considered subject to technical review.

## 4.3 Assessment

4.3.1 With the mitigation measures in place we have assessed the following noise level at the closest receptor positions:

| Location | Rating Noise Level, dB(A) *(Limit)* |
|---|---|
| | **Fully Operational (0600-2100)** |
| AP1: 1st floor residential above | 47 *(49)* |
| AP2: 1st floor residential to southeast | 49 *(49)* |

T6 Assessed plant noise emission levels at the nearest noise sensitive properties, $L_{Aeq, T}$

4.3.2 It can be seen that the plant noise limits should be achieved during the fully operational 'daytime', and therefore the noise limits outside of these hours will also be met on the assumption that they will either be non-operational or otherwise on a 'setback' duty due to the lower demand.

4.3.3 Full assessment calculations are attached as calculation sheets 17/0414/CS1-10 with summaries at positions AP1 and AP2 being the first 2 sheets presented.

# 5 Conclusion

5.1 Planning permission is being sought for the change of use of existing lower ground and part ground floor to office use Class B1 (a), together with minor external alterations at 44 Saffron Hill, London, EC1N 8FH. The development will include the installation of mechanical services plant items.

5.2 Cole Jarman have conducted an environmental noise survey at a location representative of the nearest noise sensitive properties and plant noise limits have been set considering local planning guidance.

5.3 This report has provided details of a plant noise assessment conducted for the site. The assessment has shown that with the proposed mitigation measures in place the noise limits specified should be met by the plant.

End of Section

# Glossary of Acoustic Terms

$L_{Aeq}$:

The notional steady sound level (in dB) which over a stated period of time, would have the same A-weighted acoustic energy as the A-weighted fluctuating noise measurement over that period. Values are sometimes written using the alternative expression dB(A) $L_{eq}$.

$L_{Amax}$:

The maximum A-weighted sound pressure level recorded over the period stated. $L_{Amax}$ is sometimes used in assessing environmental noise when occasional loud noises occur, which may have little effect on the $L_{Aeq}$ noise level. Unless described otherwise, $L_{Amax}$ is measured using the "fast" sound level meter response.

$L_{A10}$ & $L_{A90}$:

If non-steady noise is to be described, it is necessary to know both its level and degree of fluctuation. The $L_{An}$ indices are used for this purpose. The term refers to the A-weighted level (in dB) exceeded for n% of the time specified. $L_{A10}$ is the level exceeded for 10% of the time and as such gives an indication of the upper limit of fluctuating noise. Similarly, $L_{A90}$ gives an indication of the lower levels of fluctuating noise. It is often used to define the background noise.

$L_{A10}$ is commonly used to describe traffic noise. Values of dB $L_{An}$ are sometimes written using the alternative expression dB(A) $L_{n}$.

$L_{AX}$, $L_{AE}$ or SEL

The single event noise exposure level which, when maintained for 1 second, contains the same quantity of sound energy as the actual time varying level of one noise event. $L_{AX}$ values for contributing noise sources can be considered as individual building blocks in the construction of a calculated value of $L_{Aeq}$ for the total noise. The $L_{AX}$ term can sometimes be referred to as Exposure Level ($L_{AE}$) or Single Event Level (SEL).

End of Section

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# Figure 17/0414/F1


Title: Site plan with noise survey measurement position

Project: 44 Saffron Hill

Date: June 2017

Scale: Not to scale

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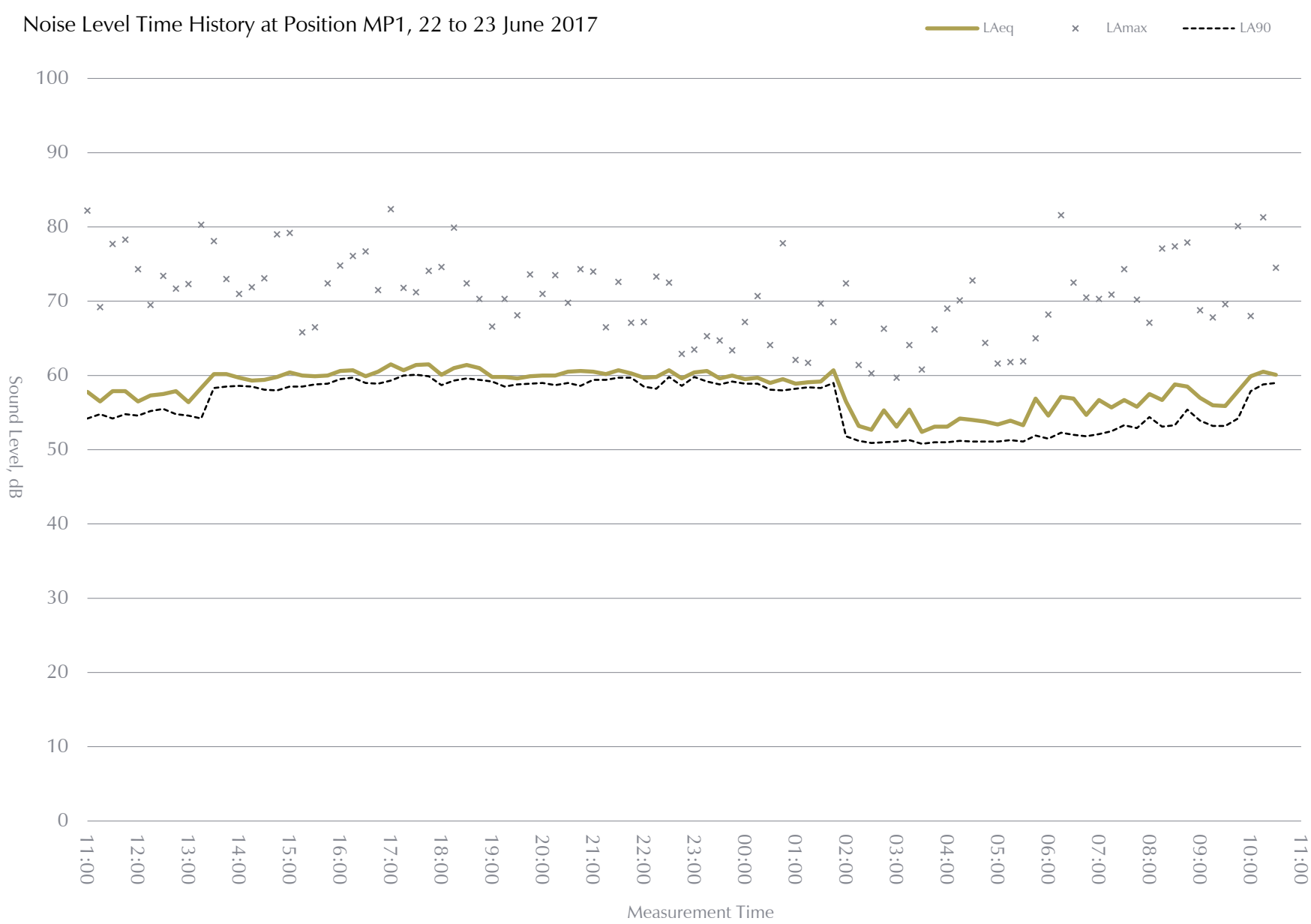



Figure 17/0414/TH01

# Specification 17/0414/SPC1

**Project:** **44 Saffron Hill**
**Subject:** **Acoustic Lining**
**Date:** **September 2017**

## 1 General

This specification defines the applicable requirements for tissue faced, mineral fibre lining to the plant room. The suppliers of the materials shall provide the necessary information and data to verify the required performance.

The supplier shall be responsible for ensuring that all the performance criteria set out herein are met by the product being offered.

## 2 Products

The acoustic lining is to be supplied in the minimum thickness stated and shall be inorganic glass fibre material with a minimum density of 48 kg/m$^3$. The material shall be provided with an erosion resistive acoustically transparent coating suitable for airflow velocities up to 15 m/s.

The sound absorption provided by the material (with and/or without the erosion resistive facing) shall meet or exceed the values tabulated below:

| **Minimum Thickness (mm)** | **Octave Band Centred Frequency (Hz)** | | | | | |
|---|---|---|---|---|---|---|
| | **125** | **250** | **500** | **1k** | **2k** | **4k** |
| 50 | 0.20 | 0.45 | 0.70 | 0.90 | 0.95 | 0.95 |

T1 Absorption Coefficients of Acoustically Absorbent Plant Area Lining

## 3 Execution

3.1 Attach to the surface of the plant room walls indicated in report 17/0414/R1.

3.2 All available portions of the area designed to receive the acoustic liner shall be completely covered. All joints shall be neatly butted and there shall be no interruptions or gaps.

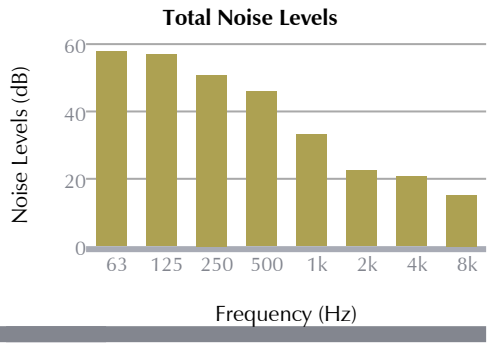
3.3 The erosion resistive face shall be orientated toward the plant room (not the wall).

3.4 The acoustic liner shall be secured with mechanical fasteners which shall compress the liner sufficiently to hold it firmly in place.

3.5 Liner shall be compressed to assure overlapped and compressed longitudinal corner joints.

End of Section

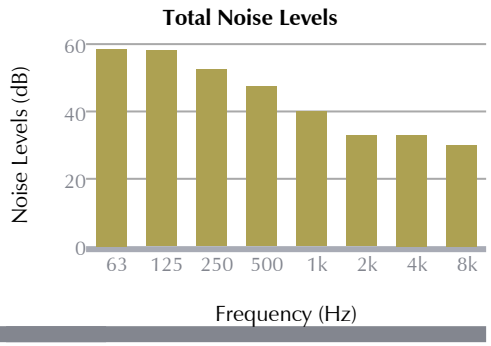
| | |
|---|---|
| **Project Name** | 44 Saffron Hill |
| **Project Reference** | 17/0414 |
| **Receiver Reference** | AP1 |
| **Description** | Apartment above |
| **Noise Limit** | 49 |
| **dBA** | 47 |




| Reference | Noise Levels (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| CU1 - Discharge | 36 | 47 | 43 | 36 | 25 | 15 | 14 | 10 |
| CU2 - Discharge | 48 | 46 | 40 | 32 | 19 | 11 | 10 | 7 |
| CU1 - Intake | 43 | 50 | 42 | 37 | 25 | 13 | 10 | 5 |
| CU2 - Intake | 57 | 55 | 49 | 45 | 31 | 21 | 18 | 11 |

External Reciever Summary 17/0414/CS2

| | |
|---|---|
| **Project Name** | 44 Saffron Hill |
| **Project Reference** | 17/0414 |
| **Receiver Reference** | AP2 |
| **Description** | Apartments Opposite |
| **Noise Limit** | 49 |
| **dBA** | 49 |




| Reference | Noise Levels (dB) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| CU2 - Discharge | 52 | 50 | 44 | 36 | 28 | 23 | 24 | 23 |
| CU1 - Discharge | 40 | 51 | 47 | 40 | 34 | 27 | 28 | 26 |
| CU1 - Intake | 43 | 50 | 42 | 38 | 31 | 22 | 21 | 18 |
| CU2 - Intake | 57 | 55 | 49 | 46 | 37 | 30 | 29 | 24 |

CU1 - Intake to AP1

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU1 - Intake | | | | | | | | | |
| **Noise Levels** | | **70.0** | **78.0** | **77.0** | **76.0** | **72.0** | **66.0** | **62.0** | **58.0** |
| ***Lw to LpRev (Src In Room)*** | | | | | | | | | |
| Receiver - Plant Room | | | | | | | | | |
| | | *5.0* | *3.3* | *-0.7* | *-2.0* | *-2.3* | *-2.5* | *-2.1* | *-2.1* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.9 | | | | | | | | |
| Length (m) | 1.8 | | | | | | | | |
| Rec or Circ - Rectangular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-2.4* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.9 | | | | | | | | |
| Height (m) | 1.8 | | | | | | | | |
| Vertical (°) | 90.0 | | | | | | | | |
| Horizontal (°) | 0.0 | | | | | | | | |
| | | *1.0* | *1.2* | *1.2* | *1.0* | *-3.5* | *-7.0* | *-7.0* | *-7.0* |
| ***10 Log (X)*** | | | | | | | | | |
| X () | 1.6 | | | | | | | | |
| | | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* |
| ***Rev to Free Field*** | | | | | | | | | |
| Scenario - Small Room, Absorb Surface | | | | | | | | | |
| | | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |
| ***Silencer*** | | | | | | | | | |
| Silencer - louvre | | | | | | | | | |
| | | *-5.0* | *-7.0* | *-10.0* | *-12.0* | *-14.0* | *-16.0* | *-13.0* | *-12.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 5.5 | | | | | | | | |
| | | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | 0.0 | | | | | | | | |
| | | *-4.9* | *-5.0* | *-5.2* | *-5.5* | *-6.2* | *-7.3* | *-8.8* | *-10.9* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP1 | | | | | | | | | |
| **Sound Pressure, Lp** | | **43.1** | **49.9** | **41.7** | **36.8** | **25.3** | **12.6** | **10.4** | **5.4** |

CU2 - Intake to AP1

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU2 - Intake | | | | | | | | | |
| **Noise Levels** | | **84.0** | **83.0** | **84.0** | **84.0** | **78.0** | **74.0** | **70.0** | **64.0** |
| ***Lw to LpRev (Src In Room)*** | | | | | | | | | |
| Receiver - Plant Room | | | | | | | | | |
| | | *5.0* | *3.3* | *-0.7* | *-2.0* | *-2.3* | *-2.5* | *-2.1* | *-2.1* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.9 | | | | | | | | |
| Length (m) | 1.8 | | | | | | | | |
| Rec or Circ - Rectangular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-2.4* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.9 | | | | | | | | |
| Height (m) | 1.8 | | | | | | | | |
| Vertical (°) | 90.0 | | | | | | | | |
| Horizontal (°) | 0.0 | | | | | | | | |
| | | *1.0* | *1.2* | *1.2* | *1.0* | *-3.5* | *-7.0* | *-7.0* | *-7.0* |
| ***10 Log (X)*** | | | | | | | | | |
| X () | 1.6 | | | | | | | | |
| | | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* |
| ***Rev to Free Field*** | | | | | | | | | |
| Scenario - Small Room, Absorb Surface | | | | | | | | | |
| | | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* | *-3.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |
| ***Silencer*** | | | | | | | | | |
| Silencer - louvre | | | | | | | | | |
| | | *-5.0* | *-7.0* | *-10.0* | *-12.0* | *-14.0* | *-16.0* | *-13.0* | *-12.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 5.5 | | | | | | | | |
| | | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | 0.0 | | | | | | | | |
| | | *-4.9* | *-5.0* | *-5.2* | *-5.5* | *-6.2* | *-7.3* | *-8.8* | *-10.9* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP1 | | | | | | | | | |
| **Sound Pressure, Lp** | | **57.1** | **54.9** | **48.7** | **44.8** | **31.3** | **20.6** | **18.4** | **11.4** |

CU1 - Discharge to AP2

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU1 - Discharge | | | | | | | | | |
| **Noise Levels** | | **72.0** | **80.0** | **79.0** | **78.0** | **74.0** | **68.0** | **64.0** | **60.0** |
| ***Bend Loss CJ*** | | | | | | | | | |
| Dimension (mm) | 600.0 | | | | | | | | |
| No. of Bends (no.) | 2.0 | | | | | | | | |
| Type - Radiussed Bend - With Vanes | | | | | | | | | |
| | | *0.0* | *0.0* | *-2.0* | *-4.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.6 | | | | | | | | |
| Length (m) | 0.6 | | | | | | | | |
| Rec or Circ - Circular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-8.0* | *-3.6* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.6 | | | | | | | | |
| Height (m) | 0.6 | | | | | | | | |
| Vertical (°) | 70.0 | | | | | | | | |
| Horizontal (°) | 45.0 | | | | | | | | |
| | | *0.0* | *0.5* | *0.5* | *0.2* | *0.2* | *-0.5* | *-0.5* | *-0.5* |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Silencer*** | | | | | | | | | |
| Silencer - CU1 - silencer | | | | | | | | | |
| | | *-3.0* | *-5.0* | *-9.0* | *-13.0* | *-13.0* | *-13.0* | *-8.0* | *-6.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 9.0 | | | | | | | | |
| | | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | -1.0 | | | | | | | | |
| | | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***Facade Reflection*** | | | | | | | | | |
| Reflection (dB) | 3.0 | | | | | | | | |
| | | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP2 | | | | | | | | | |
| **Sound Pressure, Lp** | | **39.9** | **50.9** | **47.4** | **40.2** | **34.2** | **27.4** | **28.4** | **26.4** |

CU2 - Discharge to AP2

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU2 - Discharge | | | | | | | | | |
| **Noise Levels** | | **86.0** | **85.0** | **86.0** | **86.0** | **80.0** | **76.0** | **72.0** | **66.0** |
| ***Bend Loss CJ*** | | | | | | | | | |
| Dimension (mm) | 600.0 | | | | | | | | |
| No. of Bends (no.) | 2.0 | | | | | | | | |
| Type - Radiussed Bend - With Vanes | | | | | | | | | |
| | | *0.0* | *0.0* | *-2.0* | *-4.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.6 | | | | | | | | |
| Length (m) | 0.6 | | | | | | | | |
| Rec or Circ - Circular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-8.0* | *-3.6* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.6 | | | | | | | | |
| Height (m) | 0.6 | | | | | | | | |
| Vertical (°) | 70.0 | | | | | | | | |
| Horizontal (°) | 45.0 | | | | | | | | |
| | | *0.0* | *0.5* | *0.5* | *0.2* | *0.2* | *-0.5* | *-0.5* | *-0.5* |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Silencer*** | | | | | | | | | |
| Silencer - CU2 - silencer | | | | | | | | | |
| | | *-5.0* | *-11.0* | *-19.0* | *-25.0* | *-25.0* | *-25.0* | *-20.0* | *-15.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 9.0 | | | | | | | | |
| | | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | -1.0 | | | | | | | | |
| | | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***Facade Reflection*** | | | | | | | | | |
| Reflection (dB) | 3.0 | | | | | | | | |
| | | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP2 | | | | | | | | | |
| **Sound Pressure, Lp** | | **51.9** | **49.9** | **44.4** | **36.2** | **28.2** | **23.4** | **24.4** | **23.4** |

CU1 - Discharge to AP1

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU1 - Discharge | | | | | | | | | |
| **Noise Levels** | | **72.0** | **80.0** | **79.0** | **78.0** | **74.0** | **68.0** | **64.0** | **60.0** |
| ***Bend Loss CJ*** | | | | | | | | | |
| Dimension (mm) | 600.0 | | | | | | | | |
| No. of Bends (no.) | 2.0 | | | | | | | | |
| Type - Radiussed Bend - With Vanes | | | | | | | | | |
| | | *0.0* | *0.0* | *-2.0* | *-4.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.6 | | | | | | | | |
| Length (m) | 0.6 | | | | | | | | |
| Rec or Circ - Circular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-8.0* | *-3.6* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.6 | | | | | | | | |
| Height (m) | 0.6 | | | | | | | | |
| Vertical (°) | 90.0 | | | | | | | | |
| Horizontal (°) | 0.0 | | | | | | | | |
| | | *0.0* | *0.2* | *0.2* | *0.0* | *-4.0* | *-7.0* | *-7.0* | *-7.0* |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Silencer*** | | | | | | | | | |
| Silencer - CU1 - silencer | | | | | | | | | |
| | | *-3.0* | *-5.0* | *-9.0* | *-13.0* | *-13.0* | *-13.0* | *-8.0* | *-6.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 5.5 | | | | | | | | |
| | | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | 0.0 | | | | | | | | |
| | | *-4.9* | *-5.0* | *-5.2* | *-5.5* | *-6.2* | *-7.3* | *-8.8* | *-10.9* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP1 | | | | | | | | | |
| **Sound Pressure, Lp** | | **36.3** | **46.9** | **43.3** | **35.7** | **25.0** | **15.0** | **14.4** | **10.3** |

CU2 - Discharge to AP1

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU2 - Discharge | | | | | | | | | |
| **Noise Levels** | | **86.0** | **85.0** | **86.0** | **86.0** | **80.0** | **76.0** | **72.0** | **66.0** |
| ***Bend Loss CJ*** | | | | | | | | | |
| Dimension (mm) | 600.0 | | | | | | | | |
| No. of Bends (no.) | 2.0 | | | | | | | | |
| Type - Radiussed Bend - With Vanes | | | | | | | | | |
| | | *0.0* | *0.0* | *-2.0* | *-4.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.6 | | | | | | | | |
| Length (m) | 0.6 | | | | | | | | |
| Rec or Circ - Circular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-8.0* | *-3.6* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.6 | | | | | | | | |
| Height (m) | 0.6 | | | | | | | | |
| Vertical (°) | 90.0 | | | | | | | | |
| Horizontal (°) | 0.0 | | | | | | | | |
| | | *0.0* | *0.2* | *0.2* | *0.0* | *-4.0* | *-7.0* | *-7.0* | *-7.0* |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Silencer*** | | | | | | | | | |
| Silencer - CU2 - silencer | | | | | | | | | |
| | | *-5.0* | *-11.0* | *-19.0* | *-25.0* | *-25.0* | *-25.0* | *-20.0* | *-15.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 5.5 | | | | | | | | |
| | | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* | *-14.8* |
| ***Maekawa Screening Loss*** | | | | | | | | | |
| Path Difference (m) | 0.0 | | | | | | | | |
| | | *-4.9* | *-5.0* | *-5.2* | *-5.5* | *-6.2* | *-7.3* | *-8.8* | *-10.9* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP1 | | | | | | | | | |
| **Sound Pressure, Lp** | | **48.3** | **45.9** | **40.3** | **31.7** | **19.0** | **11.0** | **10.4** | **7.3** |

CU1 - Intake to AP2

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU1 - Intake | | | | | | | | | |
| **Noise Levels** | | **70.0** | **78.0** | **77.0** | **76.0** | **72.0** | **66.0** | **62.0** | **58.0** |
| ***Lw to LpRev (Src In Room)*** | | | | | | | | | |
| Receiver - Plant Room | | | | | | | | | |
| | | *5.0* | *3.3* | *-0.7* | *-2.0* | *-2.3* | *-2.5* | *-2.1* | *-2.1* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.9 | | | | | | | | |
| Length (m) | 1.8 | | | | | | | | |
| Rec or Circ - Rectangular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-2.4* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.9 | | | | | | | | |
| Height (m) | 1.8 | | | | | | | | |
| Vertical (°) | 70.0 | | | | | | | | |
| Horizontal (°) | 45.0 | | | | | | | | |
| | | *0.5* | *0.8* | *0.8* | *0.5* | *0.5* | *-0.5* | *-0.5* | *-0.5* |
| ***10 Log (X)*** | | | | | | | | | |
| X () | 1.6 | | | | | | | | |
| | | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* |
| ***Rev to Free Field*** | | | | | | | | | |
| Scenario - Small Room, Refl Surface | | | | | | | | | |
| | | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |
| ***Silencer*** | | | | | | | | | |
| Silencer - louvre | | | | | | | | | |
| | | *-5.0* | *-7.0* | *-10.0* | *-12.0* | *-14.0* | *-16.0* | *-13.0* | *-12.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 9.0 | | | | | | | | |
| | | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* |
| ***Facade Reflection*** | | | | | | | | | |
| Reflection (dB) | 3.0 | | | | | | | | |
| | | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP2 | | | | | | | | | |
| **Sound Pressure, Lp** | | **43.2** | **50.1** | **42.1** | **37.5** | **31.3** | **22.1** | **21.5** | **18.5** |

CU2 - Intake to AP2

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 63 | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| ***Noise Source*** | | | | | | | | | |
| Noise Source - CU2 - Intake | | | | | | | | | |
| **Noise Levels** | | **84.0** | **83.0** | **84.0** | **84.0** | **78.0** | **74.0** | **70.0** | **64.0** |
| ***Lw to LpRev (Src In Room)*** | | | | | | | | | |
| Receiver - Plant Room | | | | | | | | | |
| | | *5.0* | *3.3* | *-0.7* | *-2.0* | *-2.3* | *-2.5* | *-2.1* | *-2.1* |
| ***End Reflection*** | | | | | | | | | |
| Width/Diameter (m) | 0.9 | | | | | | | | |
| Length (m) | 1.8 | | | | | | | | |
| Rec or Circ - Rectangular | | | | | | | | | |
| Free or Flush - Flush | | | | | | | | | |
| | | *-2.4* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* | *0.0* |
| ***External Grille Directivity*** | | | | | | | | | |
| Width (m) | 0.9 | | | | | | | | |
| Height (m) | 1.8 | | | | | | | | |
| Vertical (°) | 70.0 | | | | | | | | |
| Horizontal (°) | 45.0 | | | | | | | | |
| | | *0.5* | *0.8* | *0.8* | *0.5* | *0.5* | *-0.5* | *-0.5* | *-0.5* |
| ***10 Log (X)*** | | | | | | | | | |
| X () | 1.6 | | | | | | | | |
| | | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* | *2.1* |
| ***Rev to Free Field*** | | | | | | | | | |
| Scenario - Small Room, Refl Surface | | | | | | | | | |
| | | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* | *-6.0* |

| | | Octave Band Centre Frequency (Hz) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **63** | **125** | **250** | **500** | **1k** | **2k** | **4k** | **8k** |
| ***Point Source Radiation Loss*** | | | | | | | | | |
| Radiation - Quarterspherical | | | | | | | | | |
| | | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* | *-5.0* |
| ***Silencer*** | | | | | | | | | |
| Silencer - louvre | | | | | | | | | |
| | | *-5.0* | *-7.0* | *-10.0* | *-12.0* | *-14.0* | *-16.0* | *-13.0* | *-12.0* |
| ***Point Source Distance Loss*** | | | | | | | | | |
| Start Distance (m) | 1.0 | | | | | | | | |
| End Distance (m) | 9.0 | | | | | | | | |
| | | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* | *-19.1* |
| ***Facade Reflection*** | | | | | | | | | |
| Reflection (dB) | 3.0 | | | | | | | | |
| | | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* | *3.0* |
| ***External Receiver*** | | | | | | | | | |
| External Receiver - AP2 | | | | | | | | | |
| **Sound Pressure, Lp** | | **57.2** | **55.1** | **49.1** | **45.5** | **37.3** | **30.1** | **29.5** | **24.5** |

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