

# Acoustic assessment of proposed new mechanical services equipment

40 Chorlton Street, Manchester



Client: Dawnvale Group

Report Reference: 221015-R002

Date: 8<sup>th</sup> August 2023

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|-----------|------------|----------------------------|------------------------|
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## 0. SUMMARY

- 0.1. ACA Acoustics Limited has been commissioned to assess the acoustic impact of new mechanical services equipment associated with a proposed restaurant and bar at 40 Chorlton Street, Manchester.
- 0.2. The assessment is required to provide evidence that noise emissions from the equipment will not be detrimental to the amenity of nearby noise-sensitive properties and complies with the requirements of Manchester City Council's requirements such that Condition 15 of application number 120392/FO/2018 is discharged. An assessment of the potential for disturbance to nearby residential occupants has been undertaken following the procedures set out in British Standard BS 4142:2014+A1:2019 *Methods for rating and assessing industrial and commercial sound*.
- 0.3. Closest residential dwellings have been identified as apartments at 1<sup>st</sup> floor level of 40 Chorlton Street, Manchester, overlooking the equipment louvres.
- 0.4. The equipment will operate until 05:00 latest. A sound level survey has been carried out in the vicinity to establish the existing background sound level. Representative background sound levels to the rear of the site around the latest operating times of the equipment were measured at LA90 49dB. The existing acoustic climate in the vicinity is currently dominated by vehicle traffic to the front.
- 0.5. Calculations using manufacturer's sound level data for the new equipment confirm that the worst-case rating level will be LAr 44dB outside the most-affected residential properties, when assessed in accordance with BS 4142:2014+A1:2019. This is at least 5dBA below the prevailing background sound level and complies with Manchester City Council's requirements.
- 0.6. Noise from the proposed equipment should not be disturbing or detrimental to the amenity of any nearby residential occupants. The assessment includes benefit of noise-control treatments as set out in this report and no further mitigation measures would be necessary.

## 1. INTRODUCTION

New mechanical services equipment associated with ventilation and air conditioning is to be installed at 40 Chorlton Street, Manchester.

ACA Acoustics Limited has been commissioned by the client to carry out an assessment of noise emissions from the proposed mechanical plant and, where necessary, make recommendation to reduce sound levels to ensure that the amenity of nearby noise-sensitive properties is not compromised.

The assessment is required to discharge a planning condition to Manchester City Council for the development.

This report presents results of the sound level survey, calculations, assessment, and recommendations for suitable noise control treatments to comply with the required criteria.

## 2. ACOUSTIC CRITERIA

Condition 15 of decision notice to application reference 120392/FO/2018 has been issued by Manchester City Council.

*15) Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5dB (LAeq) below the typical background (LA90) level at the nearest noise sensitive location.*

*The scheme shall be submitted to and approved in writing by the City Council as local planning authority in order to secure a reduction in the level of noise emanating from the site.*

*Reason - To minimise the impact of the development and to prevent a general increase in pre-existing background noise levels around the site, pursuant to policy DM1 of the Core Strategy.*

Although not specifically noted, as this condition refers to the 'rating level' it is anticipated that the assessment should be carried out in accordance with BS 4142:2014+A1:2019.

### 3. REVIEW OF SITE LOCATION & DEVELOPMENT PROPOSALS

New mechanical services equipment associated with ventilation and air conditioning are proposed to a new restaurant and bar.

Closest residential properties are habitable rooms to an apart-hotel with first floor windows directly overlooking the equipment louvres.

A marked-up aerial photograph, showing the nominal location of new mechanical plant and the adjacent residential windows is shown in Figure 1 below.

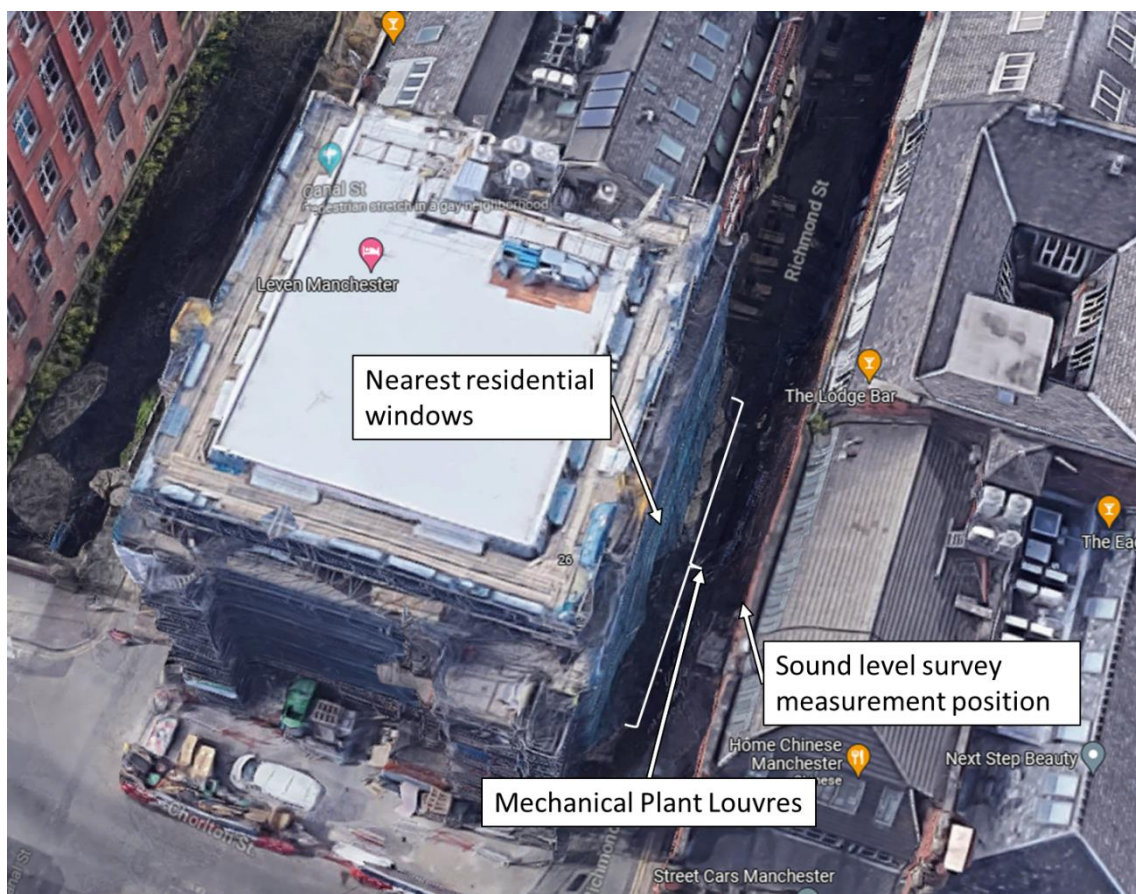


Figure 1: Aerial photograph of the site identifying closest residential windows (available at [www.google.com/maps](http://www.google.com/maps))

The proposals are for the installation of ventilation and cooling equipment, all to be installed internally and ducted to louvres to the North-West façade at ground floor level. The kitchen extract and supply system will be a re-circulating system, with no atmospheric ductwork.

It is understood the equipment will have the potential to operate to 05:00 hours latest.

## 4. SOUND LEVEL SURVEY

To assess sound levels from the new mechanical equipment it is necessary to establish existing background sound levels in the vicinity. Details of the sound level survey carried out by ACA Acoustics are provided below.

A manned background sound level survey measurement position was selected within the rear alleyway of the building at a position equivalent to windows of the neighboring residential property.

The survey was carried out during the late-night period of the 1<sup>st</sup>-2<sup>nd</sup> June 2023. Weather conditions throughout the survey remained dry and calm. The survey was conducted typically following procedures set out in BS 4142:2014+A1:2019.

The following equipment was used during the survey; the sound level meter was calibrated before the survey and checked after with no deviation noted.

| Equipment                                                  | Serial Number |
|------------------------------------------------------------|---------------|
| Nti Audio Class 1 sound level meter type XL2-TA            | A2A-16877-E0  |
| Svantek calibrator type SV33B. Compliant to IEC 60942:2003 | 57595         |

Table 1: Equipment used for the sound level survey

Results of the survey are shown in Figure 2 below.

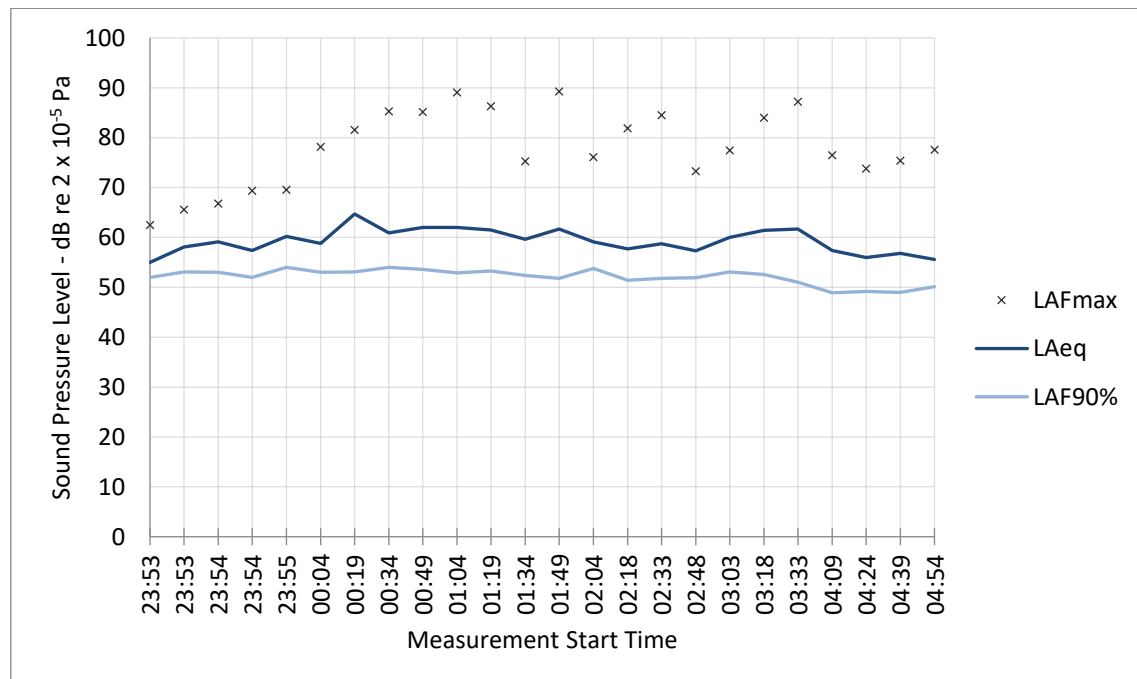


Figure 2: Sound level survey results

Dominant sound levels during the early part of the survey consisted of music and patron noise from nearby pubs and clubs, along with road traffic activity. Towards the end of the survey between 03:00 – 05:00, traffic activity was dominant as patrons left the area and the pubs and clubs closed, however the areas remained fairly busy.

In accordance with BS 4142:2014+A1:2019, the prevailing background sound level is not necessarily the lowest recorded values but rather the level that best represents the typical background sound level in the area over a defined period. A statistical analysis of the background sound levels measured has been carried out. The analysis generally follows suggested guidance contained in Section 8 of the Standard. Distribution of the measured LA90 sound levels during the latest equipment operating period is shown below.

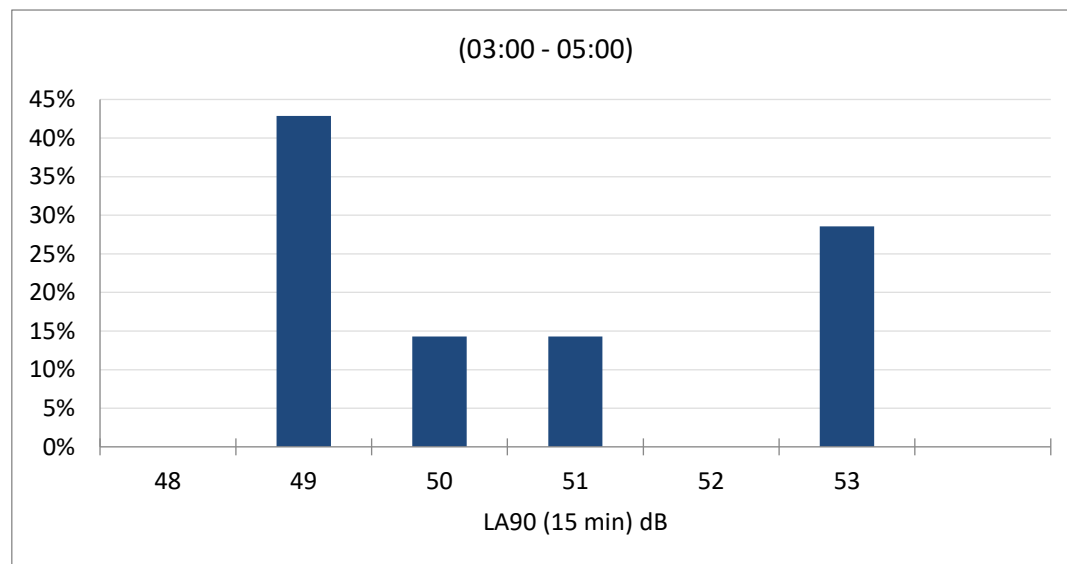


Figure 3: Statistical analysis of measured LA90 sound levels

Figure 3 confirms that during the most sensitive period of operation, the representative background sound level is LA90 49dB. In accordance with criteria issued by Manchester City Council, the cumulative rating level of the new plant during the equipment operating hours shall be designed to not exceed a level of LAr 44dB at the most affected nearby residential properties. This level is 5dBA below the representative background sound level.

## 5. ACOUSTIC ASSESSMENT

The development includes the installation of new air conditioning and catering condensers, along with new ventilation fans. Confirmation of the equipment models used in the assessment is provided in Table 2 below.

| Reference             | Equipment Model           | Air Volume             | Sound power level (LwA dB) | Quantity |
|-----------------------|---------------------------|------------------------|----------------------------|----------|
| EF RR Upper Ground    | Vent Axia ACM150          | 0.06 m <sup>3</sup> /s | 66dB                       | 1        |
| CU ESR Upper Ground   | Toshiba MMY-MAP2001HT8OP  | 4.4 m <sup>3</sup> /s  | 84dB                       | 1        |
| CU KC Lower Ground    | Toshiba MMY-MUP2001HT8P-E | 4.42 m <sup>3</sup> /s | 90dB                       | 1        |
| CU CAC Lower Ground   | Toshiba MMY-MAP2006FT8P   | 4.81 m <sup>3</sup> /s | 85dB                       | 1        |
| HRU BOH Lower Ground  | Swegon Gold F RX Size 11  | 0.6 m <sup>3</sup> /s  | FAI: 84dB<br>EAO: 84dB     | 2        |
| HRU T Lower Ground    | Swegon Gold F RX Size 004 | 0.15 m <sup>3</sup> /s | FAI: 76dB<br>EAO: 76dB     | 1        |
| HRU CA Lower Basement | Swegon Gold F RX Size 025 | 1.6 m <sup>3</sup> /s  | FAI: 89dB<br>EAO: 89dB     | 1        |

Table 2: Proposed new mechanical equipment used in the assessment

Sound emissions from the mechanical equipment can be determined from manufacturer's published data. Sound data for the Swegon HRS is not available, and so has been calculated empirically. In addition, separate inlet and discharge data is not available for the condensing units, and so the manufacturers sound power level data has been used for both inlet and discharge. Due to the nature of VRF units sound levels at the discharge are likely to be higher than those at the inlet, and so this will result in a robust assessment.

A computer model has been used to calculate the noise emissions from the proposed plant to outside the nearest noise-sensitive windows. The models for the fans incorporate corrections from the ductwork system in accordance with CIBSE Guide B4. Environmental corrections are calculated using the assessment method of ISO 9613-2:1996.

The cumulative calculated specific sound level from the plant to outside nearby residential windows with all plant operating is shown in Table 3. Summary printouts from the calculation models are included in Appendix A.

| Receptor Location                                               | Calculated Specific Sound Level |
|-----------------------------------------------------------------|---------------------------------|
| 1 <sup>st</sup> floor windows of 40 Chorlton Street, Manchester | L <sub>Aeq</sub> 41dB           |

Table 3: Calculated cumulative equipment sound levels at 1m outside noise-sensitive windows

Assessment of the calculated specific sound levels in accordance with BS 4142:2014+A1:2019, as required by Manchester City Council, is provided in Table 4 below.

It has been assumed that the condensers will operate for around 50% of the relevant assessment period, switching on/off as required by the load on the system. This is accounted for in the condenser calculation sheets included in Appendix A.

| Description                                                       |           | Relevant Clause | Commentary                                                                                            |
|-------------------------------------------------------------------|-----------|-----------------|-------------------------------------------------------------------------------------------------------|
| <b>Calculated specific sound level to noise-sensitive windows</b> | LAeq 41dB | 7.1<br>7.3.6    | All plant operating. Refer calculation sheets in Appendix A                                           |
| <b>Background sound level</b>                                     | LA90 49dB | 8.1.3<br>8.3    | Measured background sound level                                                                       |
| <b>Acoustic feature correction</b>                                | +3dB      | 9.2             | A nominal correction of +3dB has been applied to account for acoustic characteristics.                |
| <b>On time correction</b>                                         | 0dB       | 7.3             | On time correction for the condensing units has been incorporated into the calculations in Appendix A |
| <b>Rating level in accordance with BS 4142</b>                    | LAr 44dB  | 9.2             |                                                                                                       |
| <b>Excess of rating level over background sound level</b>         | -5dB      | <b>11</b>       | <b>Assessment indicates low likelihood of adverse impact</b>                                          |

*Table 4: BS 4142:2014+A1:2019 Assessment for all plant operating during the restaurant operating period to outside closest noise sensitive windows*

Table 4 shows the cumulative rating level of the proposed new equipment will be at least 5dBA below the representative background LA90 sound level to outside the closest noise-sensitive properties at any time. This achieves the criteria of Condition 15 as issued by Manchester City Council.

During periods of the day where the background sound level is higher or times when some of the equipment is not operating, such as when air conditioning condensers cycle on and off depending on the load on the system, sound levels from the equipment will be even further below the prevailing background sound level.

BS 4142:2014+A1:2019 requires an assessment to consider the context of the development, rather than simply adhering to numerical values. Considering the calculated numerical value of the specific sound, allowing a reduction through partially open windows of 15dBA, as recommended in BS 8233:2014, worst-case sound levels inside the neighbouring dwellings due to the proposed new equipment will be approximately 29dBA. This is below guideline levels for a good standard of amenity in bedrooms at night of LAeq 30dB, set out in BS 8233:2014 and is further confirmation

that sound levels from the new mechanical equipment should not be detrimental to the amenity of any noise-sensitive receptors in the vicinity.

In addition, the affected habitable rooms at first floor level are to an apart-hotel. Occupants of these rooms will be staying temporarily, and as such the impact will be slightly reduced.

The author considers that the context of the assessment further reduces slightly the initial estimate of the impact, and that sound levels from the new mechanical equipment should not be detrimental to the amenity of any residential occupiers in the vicinity. The assessment includes benefit of noise control treatments as set out in Section 6.

## **6. RECOMMENDATIONS FOR NOISE AND VIBRATION CONTROL TREATMENTS**

### **6.1 Duct-Mounted Attenuators**

It is recommended that attenuators are installed to the atmospheric sides of the fans and HRUs, and also to the inlet and discharge louvres to the condensing units housing. Insertion loss performance for the required attenuators is included in a schedule in Appendix B of this report.

Note that the dimensions and free area shown are nominal and the successful supplier should confirm their own selections to meet the minimum specified insertion loss performance and air volume requirements.

It is important airflow generated noise from the atmospheric terminal does not increase the cumulative sound level at nearby noise-sensitive properties. Suitable airflow velocity is dependent on the profile of the terminal used and should be verified with the manufacturer accordingly.

### **6.2 Vibration Isolators**

To ensure structure borne noise from the equipment is not disturbing to occupants of the adjoining units it is recommended that the fans are installed on high-performance steel spring vibration isolators, providing minimum 25mm deflection at the working load.

Flexible connections should be installed between the fans and adjoining ductwork to both atmospheric and room sides.

In addition flexible connections should be installed between the condensing units and any associated ductwork to the external louvre

All condensers should be installed on rubber or neoprene turret type isolators or pads, providing typically 8mm deflection at the working load. Should it be required, these could be upgraded to 25mm deflection steel spring mounts at a later stage.

## 7. CONCLUSION

A planning application is awaiting decision to include the installation of new mechanical services equipment associated with a restaurant and bar at 40 Chorlton Street, Manchester.

ACA Acoustics have undertaken a background sound level survey in the vicinity and calculated sound emissions from the proposed equipment using manufacturer's published acoustic data, following principles set out in BS 4142:2014+A1:2019.

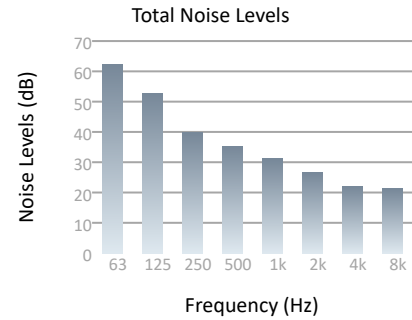
The calculated rating level for the new plant to the most-affected residential window is L<sub>A</sub>r 44dB. This is 5dBA below the prevailing background sound level in the vicinity. At this level, the new plant is described in BS 4142:2014+A1:2019 as having only a low impact. Sound emissions from the new equipment comply with the requirements of Manchester City Council.

It is the author's opinion that, allowing for the recommended noise control treatments set out in this report, the proposed new mechanical services equipment will not be detrimental to the amenity of nearby residential occupants and Condition 15 may be discharged.

## Appendix A

### Acoustic Calculations

|                          |                                |
|--------------------------|--------------------------------|
| <b>Project Name</b>      | 40 Chorlton Street, Manchester |
| <b>Project Reference</b> | 221015                         |
| <b>Reference</b>         | First floor hotel windows      |
| <b>Description</b>       |                                |
| <b>Noise Limit</b>       | -                              |
| <b>dBA</b>               | 41.4                           |



## Calculated Lp at Receptor

| Reference                    | Quantity | Noise Levels (dB) |      |      |      |       |       |       |       |
|------------------------------|----------|-------------------|------|------|------|-------|-------|-------|-------|
|                              |          | 63                | 125  | 250  | 500  | 1k    | 2k    | 4k    | 8k    |
| EF RR Upper Ground Discharge | 1        | 31.4              | 29.9 | 23.8 | 13.9 | -2.9  | 4.0   | 0.6   | 3.8   |
| HRU BOH Lower Ground EAO     | 1        | 40.5              | 28.2 | 20.7 | 21.4 | 7.0   | 7.7   | 6.1   | 5.1   |
| HRU BOH Lower Ground FAI     | 1        | 35.5              | 27.3 | 12.0 | 11.6 | 2.4   | -1.9  | -7.4  | -13.1 |
| HRU T Lower Ground EAO       | 1        | 40.5              | 32.2 | 26.6 | 14.2 | -3.6  | -0.7  | -4.1  | -2.9  |
| HRU T Lower Ground FAI       | 1        | 39.5              | 37.2 | 29.6 | 5.3  | -15.9 | -18.1 | -20.3 | -19.7 |
| HRU CA Lower Basement EAO    | 1        | 46.7              | 39.8 | 34.7 | 31.9 | 27.8  | 23.2  | 17.8  | 19.8  |
| HRU CA Lower Basement FAI    | 1        | 41.3              | 38.6 | 33.2 | 31.6 | 27.8  | 23.1  | 17.5  | 11.5  |
| CU KC Lower Ground           | 1        | 58.4              | 48.6 | 29.5 | 18.7 | 13.5  | 12.1  | 11.2  | 7.4   |
| Condenser room               | 1        | 58.1              | 48.7 | 31.7 | 15.9 | 1.9   | 7.4   | 8.2   | 10.3  |
| CU CAC Lower Ground          | 1        | 53.4              | 42.7 | 25.4 | 20.1 | 15.6  | 14.1  | 13.0  | 5.4   |

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## Calculation Sheet

## EF RR Upper Ground Discharge to First floor hotel windows

|                                                     | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------------------------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                                     | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                                 |                                   |             |             |             |             |             |             |             |
| Noise Source - EF RR Upper Ground Discharge         |                                   |             |             |             |             |             |             |             |
| <b>Noise Levels</b>                                 | <b>62.0</b>                       | <b>64.0</b> | <b>63.0</b> | <b>63.0</b> | <b>58.0</b> | <b>60.0</b> | <b>53.0</b> | <b>47.0</b> |
| <b>Silencer</b>                                     |                                   |             |             |             |             |             |             |             |
|                                                     | -7.0                              | -13.0       | -20.0       | -29.0       | -39.0       | -31.0       | -24.0       | -14.0       |
| <b>Bend Loss</b>                                    |                                   |             |             |             |             |             |             |             |
|                                                     | 0.0                               | -1.0        | -2.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        |
| <b>Rect Duct Losses</b>                             |                                   |             |             |             |             |             |             |             |
|                                                     | -0.3                              | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>End Reflection &amp; Directional Directivity</b> |                                   |             |             |             |             |             |             |             |
|                                                     | -12.6                             | -9.2        | -6.3        | -6.2        | -8.0        | -11.1       | -14.4       | -15.0       |
| <b>Dc - Reflections &amp; Directivity</b>           |                                   |             |             |             |             |             |             |             |
|                                                     | 6.0                               | 6.0         | 6.0         | 6.0         | 6.0         | 6.0         | 6.0         | 6.0         |
| <b>Adiv - Geometrical Divergence</b>                |                                   |             |             |             |             |             |             |             |
|                                                     | -19.6                             | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       |
| <b>Aatm - Atmospheric Absorption</b>                |                                   |             |             |             |             |             |             |             |
|                                                     | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | -0.1        | -0.3        |
| <b>Agr - Ground Attenuation</b>                     |                                   |             |             |             |             |             |             |             |
|                                                     | 3.0                               | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         |
| <b>Abar - Barrier Attenuation</b>                   |                                   |             |             |             |             |             |             |             |
|                                                     | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         |
| <b>External Receiver</b>                            |                                   |             |             |             |             |             |             |             |
| External Receiver - First floor hotel windows       |                                   |             |             |             |             |             |             |             |
| <b>Sound Pressure, Lp:</b>                          | <b>31.4</b>                       | <b>29.9</b> | <b>23.8</b> | <b>13.9</b> | <b>-2.9</b> | <b>4.0</b>  | <b>0.6</b>  | <b>3.8</b>  |

## Calculation Sheet

## HRU BOH Lower Ground EAO to First floor hotel windows

|                                         |     | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------------|-----|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                         |     | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                     |     |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU BOH Lower Ground EAO |     |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>               |     | <b>74.0</b>                       | <b>64.0</b> | <b>63.0</b> | <b>71.0</b> | <b>65.0</b> | <b>63.0</b> | <b>59.0</b> | <b>51.0</b> |
| <b>Silencer</b>                         |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -6.0                              | -11.0       | -18.0       | -26.0       | -33.4       | -26.9       | -20.9       | -13.0       |
| <b>Rect Duct Losses</b>                 |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                        |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                      |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend              |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -1.0                              | -2.0        | -3.0        | -3.0        | -2.6        | -2.9        | -3.0        | -3.0        |
| <b>Rect Duct Losses</b>                 |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Length (m)                              | 1.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
|                                         |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                        |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                      |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend              |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -1.0                              | -2.0        | -2.9        | -2.9        | -2.3        | -2.8        | -2.9        | -3.0        |

|                                                     |     | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |       |
|-----------------------------------------------------|-----|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                                     |     | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k    |
| <b>Rect Duct Losses</b>                             |     |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3 |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5 |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0 |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 4.0 |                                   |       |       |       |       |       |       |       |
|                                                     |     | -0.9                              | -0.4  | -0.6  | -0.4  | -0.3  | -0.4  | -0.4  | -0.4  |
| <b>End Reflection &amp; Directional Directivity</b> |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -12.6                             | -9.2  | -6.3  | -6.2  | -8.1  | -11.1 | -14.4 | -15.0 |
| <b>Dc - Reflections &amp; Directivity</b>           |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |     |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |     |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |     | 40.5                              | 28.2  | 20.7  | 21.4  | 7.0   | 7.7   | 6.1   | 5.1   |

## Calculation Sheet

## HRU BOH Lower Ground FAI to First floor hotel windows

|                                         |     | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------------|-----|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                         |     | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                     |     |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU BOH Lower Ground FAI |     |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>               |     | <b>69.0</b>                       | <b>63.0</b> | <b>53.0</b> | <b>60.0</b> | <b>44.0</b> | <b>44.0</b> | <b>37.0</b> | <b>25.0</b> |
| <b>Silencer</b>                         |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -6.0                              | -11.0       | -17.8       | -25.6       | -21.4       | -21.3       | -15.3       | -9.8        |
| <b>Rect Duct Losses</b>                 |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.1        | -0.2        | -0.2        | -0.2        |
| <b>Bend Loss</b>                        |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                      |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend              |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -1.0                              | -2.0        | -2.7        | -2.7        | -0.7        | -1.4        | -1.9        | -1.3        |
| <b>Rect Duct Losses</b>                 |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Length (m)                              | 1.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
|                                         |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.1        | -0.2        | -0.2        | -0.1        |
| <b>Bend Loss</b>                        |     |                                   |             |             |             |             |             |             |             |
| Width (m)                               | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                              | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                     | 4.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                      |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend              |     |                                   |             |             |             |             |             |             |             |
|                                         |     | -1.0                              | -2.0        | -2.3        | -2.4        | -0.3        | -0.9        | -1.4        | -0.8        |

|                                                     |     | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |       |
|-----------------------------------------------------|-----|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                                     |     | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k    |
| <b>Rect Duct Losses</b>                             |     |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3 |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5 |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0 |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 4.0 |                                   |       |       |       |       |       |       |       |
|                                                     |     | -0.9                              | -0.4  | -0.5  | -0.3  | -0.2  | -0.2  | -0.3  | -0.2  |
| <b>End Reflection &amp; Directional Directivity</b> |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -12.6                             | -9.2  | -6.3  | -6.1  | -8.1  | -11.1 | -14.4 | -14.8 |
| <b>Dc - Reflections &amp; Directivity</b>           |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |     |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |     |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |     | 35.5                              | 27.3  | 12.0  | 11.6  | 2.4   | -1.9  | -7.4  | -13.1 |

## Calculation Sheet

## HRU T Lower Ground EAO to First floor hotel windows

|                                   |     | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------|-----|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                   |     | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>               |     |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU T Lower Ground |     |                                   |             |             |             |             |             |             |             |
| EAO                               |     |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>         |     | <b>75.0</b>                       | <b>70.0</b> | <b>71.0</b> | <b>67.0</b> | <b>61.0</b> | <b>59.0</b> | <b>52.0</b> | <b>44.0</b> |
| <b>Silencer</b>                   |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -7.0                              | -13.0       | -20.0       | -29.0       | -39.0       | -31.0       | -24.0       | -14.0       |
| <b>Rect Duct Losses</b>           |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                  |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend        |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -1.0                              | -2.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        |
| <b>Rect Duct Losses</b>           |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Length (m)                        | 1.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
|                                   |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                  |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend        |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -1.0                              | -2.0        | -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    |
| <b>Rect Duct Losses</b>                             |     |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3 |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5 |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0 |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 1.0 |                                   |       |       |       |       |       |       |       |
|                                                     |     | -0.9                              | -0.4  | -0.6  | -0.4  | -0.4  | -0.4  | -0.4  | -0.4  |
| <b>End Reflection &amp; Directional Directivity</b> |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -12.6                             | -9.2  | -6.3  | -6.2  | -8.0  | -11.1 | -14.4 | -15.0 |
| <b>Dc - Reflections &amp; Directivity</b>           |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |     |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |     |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |     | 40.5                              | 32.2  | 26.6  | 14.2  | -3.6  | -0.7  | -4.1  | -2.9  |

## Calculation Sheet

## HRU T Lower Ground FAI to First floor hotel windows

|                                   |     | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------|-----|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                   |     | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>               |     |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU T Lower Ground |     |                                   |             |             |             |             |             |             |             |
| FAI                               |     |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>         |     | <b>74.0</b>                       | <b>75.0</b> | <b>74.0</b> | <b>58.0</b> | <b>45.0</b> | <b>39.0</b> | <b>34.0</b> | <b>26.0</b> |
| <b>Silencer</b>                   |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -7.0                              | -13.0       | -20.0       | -29.0       | -39.0       | -31.0       | -24.0       | -14.0       |
| <b>Rect Duct Losses</b>           |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                  |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend        |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -1.0                              | -2.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        |
| <b>Rect Duct Losses</b>           |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Length (m)                        | 1.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
|                                   |     | -0.7                              | -0.3        | -0.4        | -0.3        | -0.3        | -0.3        | -0.3        | -0.3        |
| <b>Bend Loss</b>                  |     |                                   |             |             |             |             |             |             |             |
| Width (m)                         | 0.3 |                                   |             |             |             |             |             |             |             |
| Height (m)                        | 0.5 |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)               | 1.0 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                |     |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend        |     |                                   |             |             |             |             |             |             |             |
|                                   |     | -1.0                              | -2.0        | -3.0        | -3.0        | -2.9        | -3.0        | -3.0        | -3.0        |

|                                                     |     | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |       |
|-----------------------------------------------------|-----|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                                     |     | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k    |
| <b>Rect Duct Losses</b>                             |     |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3 |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5 |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0 |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 1.0 |                                   |       |       |       |       |       |       |       |
|                                                     |     | -0.9                              | -0.4  | -0.6  | -0.4  | -0.4  | -0.4  | -0.4  | -0.4  |
| <b>End Reflection &amp; Directional Directivity</b> |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -12.6                             | -9.2  | -6.3  | -6.1  | -4.4  | -8.6  | -12.7 | -13.8 |
| <b>Dc - Reflections &amp; Directivity</b>           |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |     |                                   |       |       |       |       |       |       |       |
|                                                     |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |     |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |     |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |     | 39.5                              | 37.2  | 29.6  | 5.3   | -15.9 | -18.1 | -20.3 | -19.7 |

## Calculation Sheet

## HRU CA Lower Basement EAO to First floor hotel windows

|                                          |      | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|------------------------------------------|------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                          |      | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                      |      |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU CA Lower Basement EAO |      |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>                |      | <b>80.0</b>                       | <b>75.0</b> | <b>77.0</b> | <b>79.0</b> | <b>76.0</b> | <b>75.0</b> | <b>73.0</b> | <b>73.0</b> |
| <b>Silencer</b>                          |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -6.0                              | -11.6       | -20.4       | -28.9       | -28.1       | -27.9       | -26.5       | -20.8       |
| <b>Rect Duct Losses</b>                  |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.7                              | -0.3        | -0.4        | -0.1        | -0.1        | -0.2        | -0.2        | -0.3        |
| <b>Bend Loss</b>                         |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                       |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend               |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.9                              | -1.6        | -2.2        | -0.7        | -0.6        | -1.1        | -1.8        | -2.8        |
| <b>Rect Duct Losses</b>                  |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Length (m)                               | 1.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.7                              | -0.3        | -0.4        | -0.1        | -0.1        | -0.1        | -0.2        | -0.3        |
| <b>Bend Loss</b>                         |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                       |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend               |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.9                              | -1.3        | -1.6        | -0.3        | -0.3        | -0.6        | -1.2        | -2.7        |

|                                                     |      | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |       |
|-----------------------------------------------------|------|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                                     |      | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k    |
| <b>Rect Duct Losses</b>                             |      |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3  |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5  |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0  |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 10.7 |                                   |       |       |       |       |       |       |       |
|                                                     |      | -0.9                              | -0.3  | -0.5  | -0.2  | -0.2  | -0.2  | -0.2  | -0.4  |
| <b>End Reflection &amp; Directional Directivity</b> |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | -12.6                             | -9.2  | -6.3  | -6.2  | -8.1  | -11.1 | -14.4 | -15.0 |
| <b>Dc - Reflections &amp; Directivity</b>           |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |      |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |      |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |      | 46.7                              | 39.8  | 34.7  | 31.9  | 27.8  | 23.2  | 17.8  | 19.8  |

## Calculation Sheet

## HRU CA Lower Basement FAI to First floor hotel windows

|                                          |      | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|------------------------------------------|------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                          |      | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                      |      |                                   |             |             |             |             |             |             |             |
| Noise Source - HRU CA Lower Basement FAI |      |                                   |             |             |             |             |             |             |             |
| <b>Sound Power Levels</b>                |      | <b>74.0</b>                       | <b>73.0</b> | <b>73.0</b> | <b>62.0</b> | <b>54.0</b> | <b>51.0</b> | <b>47.0</b> | <b>50.0</b> |
| <b>Silencer</b>                          |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -5.9                              | -11.4       | -19.6       | -13.1       | -6.1        | -4.1        | -1.1        | -11.6       |
| <b>Rect Duct Losses</b>                  |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.7                              | -0.3        | -0.4        | -0.1        | -0.1        | -0.2        | -0.2        | -0.1        |
| <b>Bend Loss</b>                         |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                       |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend               |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.8                              | -1.4        | -1.4        | -0.2        | -0.6        | -1.0        | -1.6        | -0.4        |
| <b>Rect Duct Losses</b>                  |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Length (m)                               | 1.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.7                              | -0.2        | -0.3        | -0.1        | -0.1        | -0.1        | -0.2        | -0.1        |
| <b>Bend Loss</b>                         |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                | 0.3  |                                   |             |             |             |             |             |             |             |
| Height (m)                               | 0.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                      | 10.7 |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                       |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend               |      |                                   |             |             |             |             |             |             |             |
|                                          |      | -0.7                              | -1.1        | -0.8        | -0.1        | -0.3        | -0.5        | -1.0        | -0.2        |

|                                                     |      | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |       |
|-----------------------------------------------------|------|-----------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                                     |      | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k    |
| <b>Rect Duct Losses</b>                             |      |                                   |       |       |       |       |       |       |       |
| Width (m)                                           | 0.3  |                                   |       |       |       |       |       |       |       |
| Height (m)                                          | 0.5  |                                   |       |       |       |       |       |       |       |
| Length (m)                                          | 2.0  |                                   |       |       |       |       |       |       |       |
| Face Velocity (m/s)                                 | 10.7 |                                   |       |       |       |       |       |       |       |
|                                                     |      | -0.9                              | -0.3  | -0.4  | -0.2  | -0.2  | -0.2  | -0.2  | -0.2  |
| <b>End Reflection &amp; Directional Directivity</b> |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | -12.6                             | -9.2  | -6.3  | -6.2  | -8.1  | -11.1 | -14.4 | -15.0 |
| <b>Dc - Reflections &amp; Directivity</b>           |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   |
| <b>Adiv - Geometrical Divergence</b>                |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 |
| <b>Aatm - Atmospheric Absorption</b>                |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3  |
| <b>Agr - Ground Attenuation</b>                     |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   |
| <b>Abar - Barrier Attenuation</b>                   |      |                                   |       |       |       |       |       |       |       |
|                                                     |      | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   |
| <b>External Receiver</b>                            |      |                                   |       |       |       |       |       |       |       |
| External Receiver - First floor hotel windows       |      |                                   |       |       |       |       |       |       |       |
| Sound Pressure, Lp:                                 |      | 41.3                              | 38.6  | 33.2  | 31.6  | 27.8  | 23.1  | 17.5  | 11.5  |

Calculation Sheet

CU KC Lower Ground to First floor hotel windows

|                                                     |      | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------------------------|------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                                     |      | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                                 |      |                                   |             |             |             |             |             |             |             |
| Noise Source - CU KC Lower Ground                   |      |                                   |             |             |             |             |             |             |             |
| <b>Noise Levels</b>                                 |      | <b>99.0</b>                       | <b>97.0</b> | <b>91.0</b> | <b>88.0</b> | <b>85.0</b> | <b>77.0</b> | <b>70.0</b> | <b>61.0</b> |
| <b>BS 5228 % On Time</b>                            |      |                                   |             |             |             |             |             |             |             |
| On Time (%)                                         | 50.0 |                                   |             |             |             |             |             |             |             |
|                                                     |      | -3.0                              | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        |
| <b>Silencer</b>                                     |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -13.0                             | -21.0       | -32.6       | -38.1       | -37.1       | -29.9       | -23.7       | -18.3       |
| <b>Rect Duct Losses</b>                             |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -2.0                              | -1.2        | -0.8        | -0.4        | -0.4        | -0.4        | -0.4        | -0.4        |
| <b>Bend Loss</b>                                    |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                           | 1.0  |                                   |             |             |             |             |             |             |             |
| Height (m)                                          | 1.0  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                                 | 4.4  |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                                  |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend                          |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -2.0                              | -3.0        | -3.0        | -2.8        | -2.8        | -2.8        | -2.9        | -2.9        |
| <b>Rect Duct Losses</b>                             |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                           | 1.0  |                                   |             |             |             |             |             |             |             |
| Height (m)                                          | 1.0  |                                   |             |             |             |             |             |             |             |
| Length (m)                                          | 1.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                                 | 4.4  |                                   |             |             |             |             |             |             |             |
|                                                     |      | -0.7                              | -0.4        | -0.3        | -0.1        | -0.1        | -0.1        | -0.1        | -0.1        |
| <b>End Reflection &amp; Directional Directivity</b> |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -6.3                              | -6.2        | -8.2        | -11.2       | -14.5       | -15.0       | -15.0       | -15.0       |
| <b>Dc - Reflections &amp; Directivity</b>           |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | 3.0                               | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         |
| <b>Adiv - Geometrical Divergence</b>                |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -19.6                             | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       |
| <b>Aatm - Atmospheric Absorption</b>                |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | -0.1        | -0.3        |

|                                               | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |            |
|-----------------------------------------------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|
|                                               | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k         |
| <b><i>Agr - Ground Attenuation</i></b>        |                                   |             |             |             |             |             |             |            |
|                                               | 3.0                               | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0        |
| <b><i>Abar - Barrier Attenuation</i></b>      |                                   |             |             |             |             |             |             |            |
|                                               | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0        |
| <b><i>External Receiver</i></b>               |                                   |             |             |             |             |             |             |            |
| External Receiver - First floor hotel windows |                                   |             |             |             |             |             |             |            |
| <b>Sound Pressure, Lp:</b>                    | <b>58.4</b>                       | <b>48.6</b> | <b>29.5</b> | <b>18.7</b> | <b>13.5</b> | <b>12.1</b> | <b>11.2</b> | <b>7.4</b> |

## Calculation Sheet

## CU CAC Lower Ground to First floor hotel windows

|                                                     |      | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |             |
|-----------------------------------------------------|------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
|                                                     |      | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k          |
| <b>Noise Source</b>                                 |      |                                   |             |             |             |             |             |             |             |
| Noise Source - CU CAC Lower Ground                  |      |                                   |             |             |             |             |             |             |             |
| <b>Noise Levels</b>                                 |      | <b>93.0</b>                       | <b>91.0</b> | <b>85.0</b> | <b>82.0</b> | <b>79.0</b> | <b>71.0</b> | <b>64.0</b> | <b>55.0</b> |
| <b>BS 5228 % On Time</b>                            |      |                                   |             |             |             |             |             |             |             |
| On Time (%)                                         | 50.0 |                                   |             |             |             |             |             |             |             |
|                                                     |      | -3.0                              | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        | -3.0        |
| <b>Silencer</b>                                     |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -12.0                             | -20.9       | -30.8       | -30.9       | -28.9       | -21.9       | -15.9       | -14.4       |
| <b>Rect Duct Losses</b>                             |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -2.0                              | -1.2        | -0.8        | -0.4        | -0.4        | -0.4        | -0.4        | -0.4        |
| <b>Bend Loss</b>                                    |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                           | 1.0  |                                   |             |             |             |             |             |             |             |
| Height (m)                                          | 1.0  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                                 | 4.8  |                                   |             |             |             |             |             |             |             |
| Bend Type - Radius                                  |      |                                   |             |             |             |             |             |             |             |
| Type - Unlined Radius Bend                          |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -2.0                              | -3.0        | -2.8        | -2.7        | -2.8        | -2.8        | -2.9        | -2.7        |
| <b>Rect Duct Losses</b>                             |      |                                   |             |             |             |             |             |             |             |
| Width (m)                                           | 1.0  |                                   |             |             |             |             |             |             |             |
| Height (m)                                          | 1.0  |                                   |             |             |             |             |             |             |             |
| Length (m)                                          | 1.5  |                                   |             |             |             |             |             |             |             |
| Face Velocity (m/s)                                 | 4.8  |                                   |             |             |             |             |             |             |             |
|                                                     |      | -0.7                              | -0.4        | -0.3        | -0.1        | -0.1        | -0.1        | -0.1        | -0.1        |
| <b>End Reflection &amp; Directional Directivity</b> |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -6.3                              | -6.2        | -8.2        | -11.2       | -14.5       | -15.0       | -15.0       | -15.0       |
| <b>Dc - Reflections &amp; Directivity</b>           |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | 3.0                               | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         |
| <b>Adiv - Geometrical Divergence</b>                |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | -19.6                             | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       | -19.6       |
| <b>Aatm - Atmospheric Absorption</b>                |      |                                   |             |             |             |             |             |             |             |
|                                                     |      | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | -0.1        | -0.3        |

|                                               | Octave Band Centre Frequency (Hz) |             |             |             |             |             |             |            |
|-----------------------------------------------|-----------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|------------|
|                                               | 63                                | 125         | 250         | 500         | 1k          | 2k          | 4k          | 8k         |
| <b><i>Agr - Ground Attenuation</i></b>        |                                   |             |             |             |             |             |             |            |
|                                               | 3.0                               | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0         | 3.0        |
| <b><i>Abar - Barrier Attenuation</i></b>      |                                   |             |             |             |             |             |             |            |
|                                               | 0.0                               | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0         | 0.0        |
| <b><i>External Receiver</i></b>               |                                   |             |             |             |             |             |             |            |
| External Receiver - First floor hotel windows |                                   |             |             |             |             |             |             |            |
| <b>Sound Pressure, Lp:</b>                    | <b>53.4</b>                       | <b>42.7</b> | <b>25.4</b> | <b>20.1</b> | <b>15.6</b> | <b>14.1</b> | <b>13.0</b> | <b>5.4</b> |

## Calculation Sheet

## Condenser room to First floor hotel windows

|                                               |     | Octave Band Centre Frequency (Hz) |       |       |       |       |       |       |            |
|-----------------------------------------------|-----|-----------------------------------|-------|-------|-------|-------|-------|-------|------------|
|                                               |     | 63                                | 125   | 250   | 500   | 1k    | 2k    | 4k    | 8k         |
| <b>Internal Receiver Noise</b>                |     |                                   |       |       |       |       |       |       |            |
| Internal Receiver Noise - Condenser room      |     |                                   |       |       |       |       |       |       |            |
| Total Sound Pressure Level (dB)               |     | 95.5                              | 93.1  | 87.0  | 84.2  | 81.0  | 72.8  | 65.7  | 56.0       |
| <b>Diffusivity - Cd</b>                       |     |                                   |       |       |       |       |       |       |            |
| Levels after Correction                       |     | 89.5                              | 87.1  | 81.0  | 78.2  | 75.0  | 66.8  | 59.7  | 50.0 Row A |
| <b>Composite R' of structural elements</b>    |     |                                   |       |       |       |       |       |       |            |
| Facade Wall - External wall                   |     |                                   |       |       |       |       |       |       |            |
| Element Area (m2)                             | 1.0 |                                   |       |       |       |       |       |       |            |
| Facade Area                                   | 4.0 |                                   |       |       |       |       |       |       |            |
| Glazing - Plenum attenuator                   |     |                                   |       |       |       |       |       |       |            |
| Element Area (m2)                             | 3.0 |                                   |       |       |       |       |       |       |            |
| Door -                                        |     |                                   |       |       |       |       |       |       |            |
| Element Area (m2)                             | 0.0 |                                   |       |       |       |       |       |       |            |
| Roof/Ceiling -                                |     |                                   |       |       |       |       |       |       |            |
| Area of Roof (m2)                             | 0.0 |                                   |       |       |       |       |       |       |            |
| Radiating Lw                                  |     | 77.2                              | 67.8  | 50.8  | 35.1  | 21.0  | 26.5  | 27.4  | 29.8       |
| 10 log (S)                                    |     | 6.0                               | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0   | 6.0        |
| <b>Directivity Correction - Dc</b>            |     |                                   |       |       |       |       |       |       |            |
|                                               |     | -8.6                              | -8.6  | -8.6  | -8.6  | -8.6  | -8.6  | -8.6  | -8.6       |
| <b>Adiv - Geometrical Divergence</b>          |     |                                   |       |       |       |       |       |       |            |
|                                               |     | -19.6                             | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6 | -19.6      |
| <b>Aatm - Atmospheric Absorption</b>          |     |                                   |       |       |       |       |       |       |            |
|                                               |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | -0.1  | -0.3       |
| <b>Agr - Ground Attenuation</b>               |     |                                   |       |       |       |       |       |       |            |
|                                               |     | 3.0                               | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0   | 3.0        |
| <b>Abar - Barrier Attenuation</b>             |     |                                   |       |       |       |       |       |       |            |
|                                               |     | 0.0                               | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0   | 0.0        |
| <b>External Receiver</b>                      |     |                                   |       |       |       |       |       |       |            |
| External Receiver - First floor hotel windows |     |                                   |       |       |       |       |       |       |            |
| Sound Pressure, Lp:                           |     | 58.1                              | 48.7  | 31.7  | 15.9  | 1.9   | 7.4   | 8.2   | 10.3       |

## Appendix B

### Typical Noise Control Treatments

Attenuator Schedule

| Reference                             | Location | Description         | Insertion Losses (dB) |     |     |     |    |    |    |    |
|---------------------------------------|----------|---------------------|-----------------------|-----|-----|-----|----|----|----|----|
|                                       |          |                     | 63                    | 125 | 250 | 500 | 1k | 2k | 4k | 8k |
| ATT CU KC<br>Discharge<br>Attenuator  |          | 2350L 40% Free Area | 13                    | 21  | 33  | 45  | 58 | 42 | 34 | 20 |
| ATT CU CAC<br>Discharge<br>Attenuator |          | 2100L 40% Free Area | 12                    | 21  | 33  | 49  | 55 | 51 | 39 | 24 |
| ATT HRU CA FAI                        |          | 1200L 40% Free Area | 6                     | 12  | 21  | 35  | 52 | 41 | 35 | 21 |
| ATT HRU CA EAO                        |          | 1200L 40% Free Area | 6                     | 12  | 21  | 35  | 52 | 41 | 35 | 21 |
| ATT HRU T FAI                         |          | 1050L 40% Free Area | 7                     | 13  | 20  | 29  | 39 | 31 | 24 | 14 |
| ATT HRU T EAO                         |          | 1050L 40% Free Area | 7                     | 13  | 20  | 29  | 39 | 31 | 24 | 14 |
| ATT EF RR<br>Discharge                |          | 1050L 40% Free Area | 7                     | 13  | 20  | 29  | 39 | 31 | 24 | 14 |
| ATT HRU BOH FAI                       |          | 900L 40% Free Area  | 6                     | 11  | 18  | 26  | 34 | 27 | 21 | 13 |
| ATT HRU BOH<br>EAO                    |          | 900L 40% Free Area  | 6                     | 11  | 18  | 26  | 34 | 27 | 21 | 13 |
| ATT Condenser<br>Room Plenum          |          | 2400L 45% Free Area | 11                    | 20  | 31  | 46  | 55 | 41 | 33 | 20 |

Notes:

1. All dimensions in mm
2. Performance shown as static insertion loss. Dynamic insertion loss performance allowing for airflow generated noise is shown on the relevant calculation sheet.
3. Selections are nominal and the successful supplier should ensure their proposal achieves the minimum required static and dynamic insertion loss performance.