Measurement of Machine Noise Emissions

Prepared: 28th July 2013

Report No – 14076-1
Client – Air Handlers (Northern) Ltd
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2. Scope

2.1.1. This report details the findings of a machinery sound power and pressure survey of an Air Handling Unit (AHU) at Air Handlers (Northern) Ltd, Albert Proctor House, Bute St, Salford, Manchester M50 1DU.

2.1.2. The sound power measurement and calculation procedure was in accordance with ISO 3746:2009 “Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane”.
3. **Introduction**

3.1. **Introduction**

3.1.1. The client scheduled a witnessed sound pressure level / power Level test at the Northern factory in Salford in order to establish the machinery noise emissions. The sound emissions from the Air Handlers AHU have been measured using guidance from international measurement standards.

3.2. **Measurement Criteria**

3.2.1. It is understood that as part of the validation requirement for the air handling plant supplied to the Bodleian Library, University of Oxford a validated witnessed test is required in order to assess the sound pressure level break out / sound power levels generated by the plant.

3.2.2. One or more of the following noise data may be required:

- Sound power level;
- Sound pressure level at 1 m distance, free field condition;
- Sound pressure level at operator’s position, free field condition.

3.2.3. For sound power measurements, standards in the ISO 3740 series or ISO 9614 series should be used.

3.2.4. The AHU is remotely operated and there is no defined operator’s position; therefore, this element has been excluded from the report.

3.3. **BS EN ISO 3746:2009**

3.3.1. The ISO3740 series of documents specifies various methods for determining the sound power levels of machines, equipment and their sub-assemblies. BS EN ISO3746:2009 specifies a method for measuring the sound pressure levels of a noise source and the calculation procedure to derive the item’s sound power level.

3.3.2. The enveloping surface method can be used for any of three grades of accuracy and is used in this instance for grade 3 (survey) accuracy.
4. Survey

4.1. Machine/equipment under test

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Air Handling Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacturer</td>
<td>Air Handlers (Northern) Ltd</td>
</tr>
<tr>
<td>Part</td>
<td>Bodleian Library</td>
</tr>
<tr>
<td>Serial Number</td>
<td>AHN5952-4</td>
</tr>
<tr>
<td>Year of Manufacture</td>
<td>2013</td>
</tr>
<tr>
<td>Dimensions</td>
<td>5.15m x 1.31m x 1.82m</td>
</tr>
</tbody>
</table>

*Table 1 - Machine/equipment details*

4.2. Test Conditions

4.2.1. The air handling unit was run at full load for the duration of the measurements. The unit’s main noise sources were the supply and extract fan/motor units; as part of a complete machine, all the metal components were radiating/re-radiating sound. It was noted that the noise emissions from the unit were relatively uniform across the casework area.

4.2.2. The unit was placed on a concrete (acoustically hard) floor inside the factory at Air Handlers (Northern) Ltd. An indicative layout plan is shown in Figure 1. Other items of equipment and machinery were present in the workshop but none breached the measurement surface.
4.3. Acoustic environment

4.3.1. The workshop consisted of a concrete floor, concrete block walls, and a metal cladding exposed roof. The workshop contained a number of smaller pieces of equipment and two further air handling units that were under construction. The approximate surface areas of the workshop walls, floor and ceiling were as follows:

- Concrete floor – 1800m²
- Concrete block walls – 1260m²
- Metal clad ceiling – 1850m²

4.3.2. There were few absorptive materials in the room and its total volume was approximately 12600m³.

4.4. Instrumentation

4.4.1. The following instrumentation was used during the survey:
4.4.2. In addition a sound level monitoring position was placed inside the AHU to monitor the steady state sound pressure level for the duration of the test. The details are tabulated below:

<table>
<thead>
<tr>
<th>Type</th>
<th>Manufacturer</th>
<th>Product Code</th>
<th>Serial Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sound Level Meter</td>
<td>Norsonic</td>
<td>Nor118</td>
<td>31477</td>
</tr>
<tr>
<td>Calibrator</td>
<td>Norsonic</td>
<td>Nor1251</td>
<td>33376</td>
</tr>
</tbody>
</table>

Table 2 – Layout of the test environment

4.4.3. The equipment was calibrated before and after the surveys. The calibration was as follows:

<table>
<thead>
<tr>
<th>Type</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norsonic 118</td>
<td>113.9</td>
<td>113.9</td>
</tr>
<tr>
<td>Norsonic 140</td>
<td>113.9</td>
<td>113.9</td>
</tr>
</tbody>
</table>

Table 4 – Calibration details

4.5. Survey Method

4.5.1. Sound pressure measurements were made at discrete points on a defined measurement surface as prescribed by BS EN ISO 3746:2009.

4.5.2. An imaginary reference box was considered, a parallelepiped encompassing all parts of the machinery. Because of the shape of the air handling unit, the reference box was defined by the machine itself.

4.5.3. The measurement surface was taken to be a parallelepiped with its sides 1m from the AHU. Sound pressure level measurements were made at the positions defined by the procedure in Annex C of BS EN ISO 3746: 2009 of each side of this measurement surface (7 in total). Figure 2 shows the reference box/machine, measurement surface, and the discrete measurement positions.

4.5.4. The acoustics of the measurement environment were taken into account by measuring the reverberation time of the room. Measurements were made according the survey grade method contained in ISO 3382-2:2008 “Acoustics – measurement of room acoustic parameters – Part 2: Reverberation time in ordinary rooms”.

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Figure 2 – An illustration showing the reference box, measurement surface and measurement positions for the survey.

4.6. Measurement timescale

4.6.1. The continuous equivalent sound pressure level was measured for 1-min at each measurement location. The following measurements were recorded:

\[ L_{Aeq,30\ sec} \]
4.7. Internal Measurement

4.7.1. The continuous equivalent sound pressure level was measured inside the AHU over 10 second intervals. The data shows the continuous sound pressure level inside the AHU was steady over the survey period. The minimum sound pressure level was 99.7 dB LAeq,T and the maximum during the survey period was 100.6 dB LAeq,T. The “A” Weighted Sound Pressure Level is graphically illustrated below:

![Figure 3: Sound Pressure Levels Lp internal to ANU Fan Section](image)

4.8. Sound pressure level at 1m, SPL

4.8.1. The average sound pressure level in the jth frequency band 1m from the air handling unit was calculated by averaging the sound pressure level measurements at positions 1-7 using:

$$\bar{L}_{p_j} = 10 \log \left( \frac{1}{N} \sum_{i=1}^{N} 10^{L_{p_i}/10} \right)$$

4.8.2. Where:

- $L_{p_j}$ is the average sound pressure level in the jth frequency band;
4.8.3. The average corrected sound pressure level for the $j$th frequency band is given by the following:

$$L_{avg} = L_{pf} - K_1 - K_2$$

- $K_1$ is the background correction for background noise, see appendix for details;
- $K_2$ is the correction due to the reverberant field, see appendix for details.

4.9. Sound power level, SWL

4.9.1. The sound power level was calculated from the sound pressure level measurements made over the measurement surface defined in Figure 2. The sound power level is defined as:

$$L_{wj} = L_{pf} + 10 \log_{10} \frac{S}{S_0} \ dB$$

4.9.2. Where:

- $L_{wj}$ is the sound power level in the $j$th frequency band
- $S$ is the area of the measurement surface
- $S_0$ is 1m
5. Results

5.1. Sound pressure level at 1m, SPL

5.1.1. The sound pressure levels at 1m have been corrected for both background noise and the reverberant field such that they represent the free-field condition. NOTE: dB(A) figure taken from sound level meter record i.e. not calculated from spectrum.

<table>
<thead>
<tr>
<th>dB(A)</th>
<th>Octave band centre frequency, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL (dB)</td>
<td>31.5</td>
</tr>
<tr>
<td>49.7</td>
<td>60.0</td>
</tr>
</tbody>
</table>

Table 5 – Sound pressure level results – Free field

5.2. Sound power level, SWL

5.2.1. The sound power levels have been corrected for both background noise and the reverberant field. NOTE: dB(A) figure taken from sound level meter record i.e. not calculated from spectrum.

<table>
<thead>
<tr>
<th>dB(A)</th>
<th>Octave band centre frequency, Hz</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWL (dB)</td>
<td>31.5</td>
</tr>
<tr>
<td>68.9</td>
<td>79.3</td>
</tr>
</tbody>
</table>

Table 6 – Sound power level results

6. Conclusions

6.1.1. The sound emissions from the Bodleian Library AHU have been measured and evaluated in accordance with BS EN ISO3746: 2009 such that the following quantities have been calculated:

- Sound power level;
- Sound pressure level at 1 m distance, free field condition.

Dr Bill Whitfield BA, MSc, PhD, MIOA
Noise and Vibration Consultant
### Bibliography

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN ISO 3746:2009</td>
<td>“Acoustics — Determination of sound power levels of noise sources using sound pressure — Survey method using an enveloping measurement surface over a reflecting plane”.</td>
</tr>
</tbody>
</table>
8. Appendix

8.1. Correction due to background noise

8.1.1. The measured sound pressure levels may need to be corrected for any background noise that was present during the survey. The background correction is determined using the following equation:

$$K_1 = -10 \log \left( 1 - 10^{-0.1 \left( \frac{L_{pA}}{L_{pA}} - \frac{L_{pA}'}{L_{pA}'} \right)} \right)$$

8.1.2. Where:

- $K_1$ is the correction for background noise
- $L_{pA}$ is the average A-weighted sound pressure level
- $L_{pA}'$ is the average A-weighted background noise sound pressure level

Average A-weighted sound pressure level, $L_{pA}$  
51.2dB

Average A-weighted background noise sound pressure level, $L_{pA}'$  
36.7dB

Correction for background noise, $K_1$  
0dB

(Background noise is sufficiently low to be neglected)