noise.co.uk
T+44(0)2476 545 397
F+44(0)2476 545 010
Meadow View
Newnham Grounds
Kings Newnham Lane
Bretford
Warwickshire
CV23 0JU

Measurement of Machine Noise Emissions

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

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1. Contents

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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.

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4. Survey

4.1. Machine/equipment under test

Equipment Type	Air Handling Unit

Manufacturer	Air Handlers (Northern) Ltd
Part	Bodleian Library
Serial Number	AHN5952-4
Year of Manufacture	2013
Dimensions	5.15m x 1.31m x 1.82m

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.

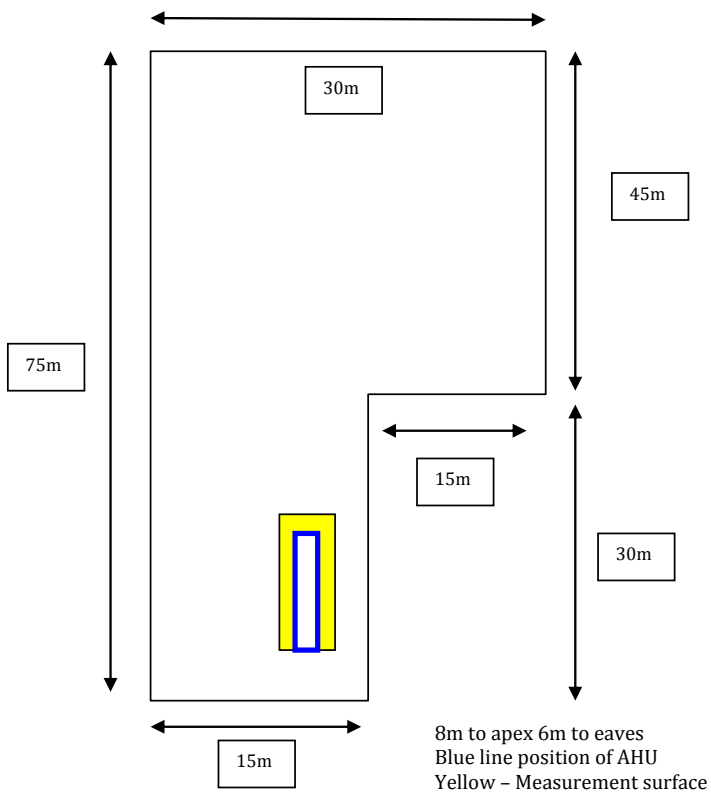

Figure 1 – Layout of the test environment (not to scale)

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 – 1800m^2
- Concrete block walls – 1260m^2
- Metal clad ceiling – 1850m^2

4.3.2. There were few absorptive materials in the room and its total volume was approximately 12600m^3.

4.4. Instrumentation

4.4.1. The following instrumentation was used during the survey:

Type	Manufacturer	Product Code	Serial Number
Sound Level Meter	Norsonic	Nor118	31477
Calibrator	Norsonic	Nor1251	33376

Table 2 – Layout of the test environment

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:

Type	Manufacturer	Product Code	Serial Number
Sound Level Meter	Norsonic	Nor140	1405533
Calibrator	Norsonic	Nor1251	33767

Table 3 – Layout of the test environment

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

	Before	After
Norsonic 118	113.9	113.9
Norsonic 140	113.9	113.9

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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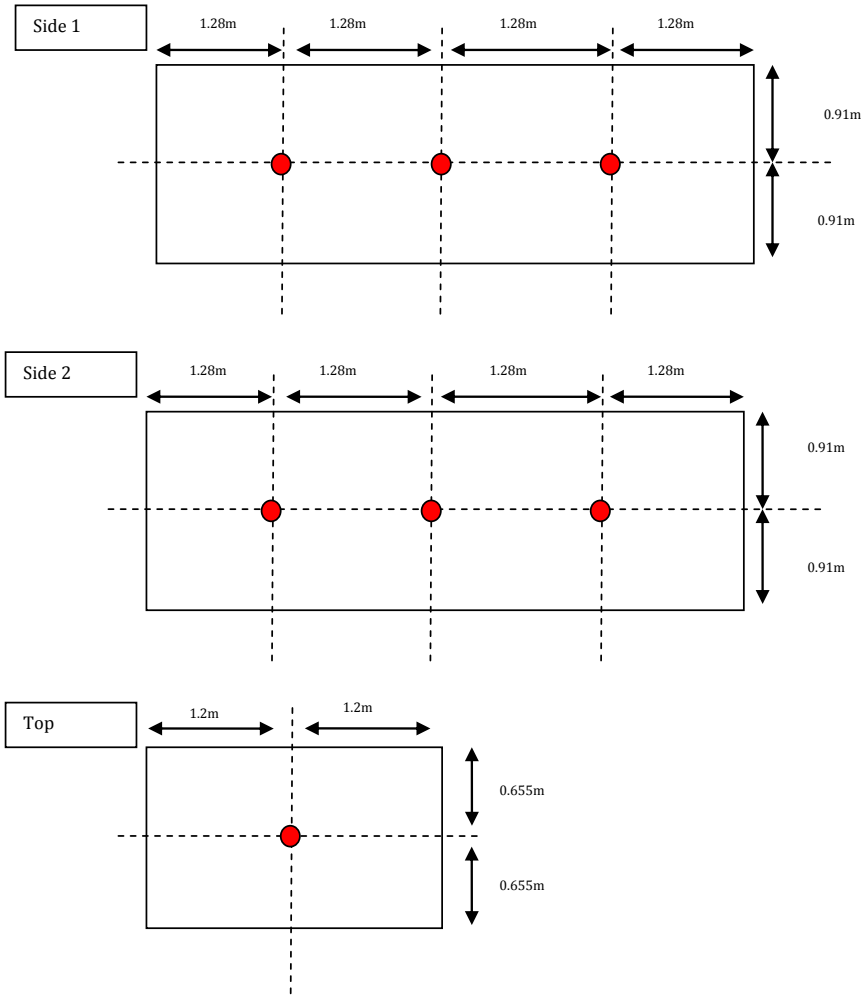

Figure 2 – An illustration showing the reference box, measurement surface and measurement positions for the survey.

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:

$L_{Aeq,30\ sec}$

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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 99.7dB LAeq,T and the maximum during the survey period was 100.6dB LAeq,T. The "A" Weighted Sound Pressure Level is graphically illustrated below:

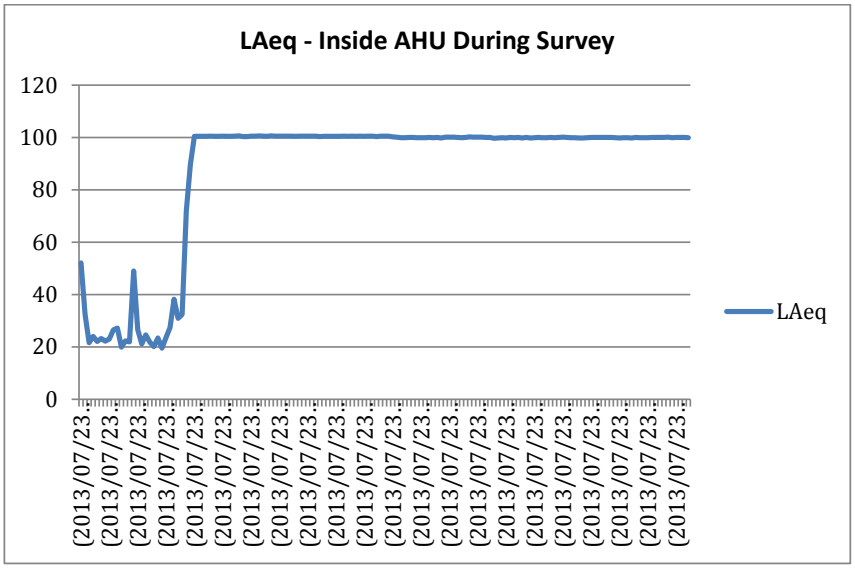

Figure 3: Sound Pressure Levels Lp internal to ANU Fan Section

4.8. Sound pressure level at 1m, SPL

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

$$\overline{L_{p_j}} = 10 Log_{10}\left[\frac{1}{N}\sum_{i=1}^{N} 10^{L_{p\,ji}/10}\right]$$

4.8.2. Where:

$\overline{L_{p_j}}$ is the average sound pressure level in the j^{th} frequency band;

$L_{p_{j,i}}$ is the sound pressure level in the j[th] frequency band at the i[th] measurement position;

4.8.3. The average corrected sound pressure level for the j[th] frequency band is given by the following:

$$\overline{L_{pf_j}} = \overline{L_{p_j}} - K_1 - K_2$$

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:

$$L_{wj} = \overline{L_{pf_j}} + 10\log_{10}\frac{S}{S_0}\,dB$$

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

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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.

	dB(A)	Octave band centre frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
SPL (dB)	49.7	60.0	56.3	49.9	52.8	44.8	43.5	42.5	39.0	31.2

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.

	dB(A)	Octave band centre frequency, Hz								
		31.5	63	125	250	500	1k	2k	4k	8k
SWL (dB)	68.9	79.3	75.6	69.1	72.1	64.1	62.8	61.8	58.3	50.5

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

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7. Bibliography

Reference	Title
BS EN 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".*
ISO 3382-2:2008	*"Acoustics – measurement of room acoustic parameters – Part 2: Reverberation time in ordinary rooms".*

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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:

$$K_1 = -10Log\left(1-10^{-0.1\left(\overline{L_{pA}}-\overline{L'_{pA}}\right)}\right)$$

8.1.2. Where:

K_1 is the correction for background noise

$\overline{L_{pA}}$ is the average A-weighted sound pressure level

$\overline{L'_{pA}}$ is the average A-weighted background noise sound pressure level

Average A-weighted sound pressure level, $\overline{L_{pA}}$	51.2dB
Average A-weighted background noise sound pressure level, $\overline{L'_{pA}}$	36.7dB
Correction for background noise, K_1	0dB

(Background noise is sufficiently low to be neglected)