ENVIRONMENTAL NOISE ASSESSMENT
AT
MURPHY BREWERY.

Report Dated:
25 June 2015

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Kilmoney,
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http://www.env.ie/
Environmental Noise Assessment at Murphy Brewery.

Ms. Niamh Culhane, Heineken Ireland, Murphy Brewery, Leitrim Street, Cork.

150212-02

25 June 2015

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**APPENDIX I**

Figure 1: Approximate Location of off-site Noise Monitoring Position. Photographs of off-site Noise Monitoring Position.

**APPENDIX II**

Extracted monitoring results and one-third octave band analysis results.

**APPENDIX III**

Summary of Met Eireann data for Cork Airport Instrumentation and external calibration details

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Glossary
1. Introduction

*Moloney & Associates* were commissioned by Heineken Ireland to undertake an Environmental Noise Assessment for its facility at the Murphy brewery in Blackpool, Cork.

The survey and assessment work was undertaken by Dermot Moloney, MSc, BSc, MEnvSc, MIOA, MInstSCE, CSci.

Heineken Ireland is hereinafter referred to as the Client.
2. Scope and Methodology of the Survey

The Client operates a brewery at the Blackpool site and there are a number of significant noise sources which operate on the site. A previous study (Report Number: 140334, dated 15 July 2014) identified tonal noise emanating at the plant which was perceptible at certain noise sensitive locations. Furthermore it is understood that noise complaints have been made about night-time noise emissions, although details of these complaints have not been reviewed.

The primary objective of this study was to identify the likely source of the tonal noise emissions at the brewery with a view to developing appropriate controls.

After a preliminary review of the site operations the dominant noise sources with potential tonal properties were identified as follows:

- Condenser water pumps (2 No.) – fixed speed
- Sabroe Compressors (3 No.) – variable speed
- Stadco Cooling fans (4 No.) – fixed speed
- BBT pumps (3 No.) – fixed speed
- Water transport pumps (4 No.) – fixed speed
- Wort chilling pump – (1 No.) – fixed speed
- Water supply pumps – (2 No.) – fixed speed
- CO₂ purging.

Mobile plant and equipment such as road tankers, lorries and forklift trucks operate during daytime at the facility. However, these mobile sources operate intermittently and are not considered to be the dominant source of off-site noise. Furthermore none of these normally operate during night-time and were thus excluded from the study.

For the purpose of the survey and assessment, efforts were made to describe and assess the likely dominant sources of noise associated with the night-time operations at the facility.

A series of noise measurements were made under controlled conditions by switching certain items of plant on and off. This was achieved by liaising with site management and undertaking ‘source measurements’ under a specific set of operational conditions, which were agreed in advance and noted during the survey.

The survey methodology was designed to rank the dominant noise sources at the site and to focus in on potentially problematic emissions. In some cases, differences in ambient noise levels were identified as a result of an individual item of equipment having being switched on or off.

The survey work was undertaken during the 22nd of May 2015 during evening and night-time and was attended by Dermot Moloney (the assessor).

The survey methodology was primarily based upon procedures set out in the International Standard, ISO 1996 (Acoustics – description and measurement of environmental noise).
The instrumentation used was a Bruel & Kjaer Modular Real-time Analyser – B&K 2250-L, Type 1 Precision Sound Level Meter with Half Inch, Free Field Microphone - B&K, Type 4950. The microphone was fitted with a windshield (model UA 0237) during the measurements and the instrument was mounted on a tripod, 1.5 m above ground level.

The survey instrumentation was calibrated before and after each series of measurements with no significant drift recorded. (Instrumentation and external calibration details are presented in Appendix III of this report).

One monitoring position was selected for the off-site noise assessment, as follows:

- Position A: This off-site position is located to the west of the brewery on an elevated position close to the junction of Eason’s Hill and John Street Upper.

The selection of this monitoring position was somewhat affected by access issues and practical constraints, however, it has a direct line of sight into the brewery. This facilitated a view of some of the likely dominant noise sources and is considered to be a useful position to assess the off-site impact of the facility’s noise emissions. The approximate location of the position is shown in Figure 1 (Appendix I) along with photographs. The intervening ground between Position A and the Client’s noise sources was hard (concrete and tarmac/dam).

In addition, to assessing noise at Position A, a series of measurements were taken at distances of c. 1 – 2 metres from certain specified equipment. Representative noise measurements were taken using the A-Weighted network and fast-response. The monitoring equipment was manned throughout the sampling intervals and comments were recorded in order to aid the interpretation of the results.

Throughout the monitoring, the microphone was situated 1.5 m above ground level and the following "A-Weighted" data was determined for each sampling period:

- $L_{\text{max}}$: The maximum noise level during the measurement period. (This parameter is usually measured using fast response).
- $L_{10,T}$: The noise level exceeded for 10% of the measurement period. (This level is representative of the typical peaks and it is most frequently used in the assessment of traffic noise.)
- $L_{90,T}$: The noise level exceeded for 90% of the measurement period. (This level is taken to represent the "background noise" level.)
- $L_{\text{eq},T}$: The equivalent continuous noise level for the measurement period. (This is defined as the sound level of a steady sound having the same energy as a fluctuating sound over the specified measuring period. $L_{\text{Aeq}}$ is the usual index used in planning and licensing conditions).
An ‘A-weighted decibel’ – dBA or dB(A) – is a measure of the overall noise level of sound across the audible frequency range (20 Hz to 20 kHz). A numerical (A-frequency) weighting is applied to compensate for the varying sensitivity of the human ear to sound at different frequencies.

A series of short-term ‘controlled noise measurements’ was undertaken in order to evaluate the dominant noise sources and the characteristics of same by measuring temporal variations in noise levels and undertaking frequency analysis under controlled conditions. It is noteworthy that in order to facilitate this form of survey work, interference with plant production activities had to be facilitated. The writer would like to acknowledge the extensive cooperation received from the Client’s management and production team, throughout the survey.

The results of the noise survey are presented in a series of charts and bar graphs which are presented in Appendix II of this report. A summary of the results is presented in Section 3 of this report.

One-third octave band frequency analysis was also undertaken during the survey and key extracts from the frequency analysis have been enclosed in Appendix II. Sound recordings were also made at the time of sampling using an Olympus Digital Recorder (LS 14). All of the recordings at the specified equipment have been retrieved and these can be subjected to narrow-band analysis. However, difficulties arose in matching these noise sources with the ambient noise at Position A, due predominantly to wind generated noise. (This is further addressed in section 3).
3. Survey Results

Detailed results of the noise monitoring and assessment programme were logged and analysed using a proprietary software package (Evaluator Type 7820, Bruel & Kjaer). The data along with an analysis and description of same are presented in Appendix I.

In any survey, noise monitoring results describe the noise environment at the specified positions during the time of measurement. In this instance we have endeavoured to associate the noise at a particular point in time with a specific activity/item of equipment. To achieve this, measurements were undertaken under controlled conditions and the assessor liaised with on-site personnel to verify the sampling conditions. Thus we measured noise at a specified position under conditions when a specified source was either operational or had been deliberately switched off. This latter condition has been described as ‘background noise’ for the purpose of this report. Thus, the difference between the background noise and the operating noise for each source helps to describe its potential impact.

When we measure ambient noise, we effectively describe the total noise at a given position, made up from many sources. In many instances the $L_{Aeq}$ level can be significantly affected by extraneous noises, e.g., road traffic, bird-song etc.

The ambient noise in the vicinity of the Client’s site can be significantly affected by intermittent road traffic, pedestrians and domestic noise. Where a significant source of extraneous noise was identified during the survey, this was noted and attempts were made to exclude its influence on the measured results. However, throughout the survey intermittent road traffic noise and particularly wind generated noise (arising from gusting and changes in wind speed direction) had a significant effect and confounded the measurements at Position A.

In attempts to minimise the effect of extraneous noise, in some cases, short term measurements were undertaken (typically 15 second’s duration). Whilst the effect of road traffic noise was somewhat minimised by using pausing and excluding techniques during sample periods when traffic noise was deemed to intrude, it was not possible to exclude the effect of wind generated noise at Position A. Despite attempts at repeat measurements, the Position A measurements were unreliable and in some instances, ambient noise levels were deemed to be higher when certain noise sources at the brewery were switched off. In most of the measurements at Position A, the difference in noise attributable to switching equipment on and off could not be heard or assessed, due primarily to wind and to a lesser extent road traffic.

In assessments of this type the most pertinent findings arise from situations in which there was a discernible change in the ambient noise as a result of a modification to plant operational conditions. Sometimes changes are more clearly audible and in some cases the dBA values do not reflect the change in the noise environment. However, comments were recorded in order to assist in the interpretation of the data.
A summary of the relevant monitoring results is presented in Table 3. This summary excludes all measurements which were significantly affected by road traffic noise and all duplicate measurements.

**Table 3.1: Summary of on-site Noise Monitoring Results.**

<table>
<thead>
<tr>
<th>Monitoring Position</th>
<th>Operational Conditions/Observations</th>
<th>$L_{eq}$ (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Midway between condenser water pumps</td>
<td>Condenser water pumps - off</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td>Condenser water pumps - on</td>
<td>79</td>
</tr>
<tr>
<td>Midway between Stadco Cooling fans</td>
<td>Cooling fans – off</td>
<td>64</td>
</tr>
<tr>
<td></td>
<td>Cooling fans – on (fans tonal)</td>
<td>90</td>
</tr>
<tr>
<td>c. 2 metres from BBT pumps</td>
<td>BBT pumps – off</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>BBT pumps – on</td>
<td>73</td>
</tr>
<tr>
<td>c. 1.5 metres from Wort Chilling Pump</td>
<td>Wort Chilling Pump – off</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>Wort Chilling Pump – on</td>
<td>86</td>
</tr>
<tr>
<td>c. 2 metres from Water supply pump</td>
<td>Water supply pump – off</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>Water supply pump – on</td>
<td>77</td>
</tr>
</tbody>
</table>

Monitoring was conducted during dry weather at a time when the weather forecast had predicted relatively light breezes. During the survey external air temperature measurements were undertaken using a Testo 615 digital hygrometer. In addition, wind speed measurements were undertaken using an electronic rotation vane anemometer (Kestrel 1,000) and details of the wind direction were noted using a compass.

Metrological measurements were made externally at approximately 2 m above ground and have been logged. A summary of the weather conditions at the Met Eireann Cork Airport station is presented in Table 2 (Appendix I).

It is clear from the on-site observations and metrological measurements that localised and temporal variations in wind speed and direction resulted in a significant effect on the propagation of noise during the survey. For this reason, the measurements at Position A will need to be repeated. Nonetheless a summary of the Position A measurement data is provided in Table 3.2.
Table 3.2: Summary of off-site Noise Monitoring Results (Position A).

<table>
<thead>
<tr>
<th>Operational Conditions/Observations</th>
<th>$L_{eq}$ (dBA)</th>
<th>$L_{90}$ (dBA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All plant operating normally</td>
<td>53</td>
<td>51</td>
</tr>
<tr>
<td>Compressors (Sabroe &amp; Stal) switched off</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>Condenser pumps switched off</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>All plant operating normally</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>Stadco cooling fans switched off (very noticeable reduction in ambient noise)</td>
<td>50</td>
<td>46</td>
</tr>
<tr>
<td>BBT pumps switched off</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>All plant operating normally</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>Water supply pump switched off</td>
<td>54</td>
<td>51</td>
</tr>
<tr>
<td>Wort Chilling Pump switched off</td>
<td>53</td>
<td>52</td>
</tr>
<tr>
<td>CO2 &amp; Freon compressors switched off</td>
<td>51</td>
<td>50</td>
</tr>
<tr>
<td>All plant operating normally</td>
<td>53</td>
<td>51</td>
</tr>
</tbody>
</table>

Short-term variations in wind speed and direction resulted in a significant effect on the propagation of noise during the survey and the measurement results at Position A were significantly affected by wind-generated noise. The extent of its contribution cannot be accurately determined and for this reason it is not advisable to rely on these measurement data. For this reason additional survey work is required at Position A.
4. Criteria and Conclusions

In practice noise limits have been established for industrial and commercial activities having regard to local circumstances and the need for environmental protection. The pertinent IPPC licence and EPA Guidance (NG4) prescribe that activities on site must not give rise to noise levels off-site at any noise sensitive location which exceed the sound pressure limits of 55 dB(A) during the day (08:00 to 23:00 hours) and 45 dB(A) at night time (23:00 to 07:00 hours). In addition, there shall be no clearly audible tonal or impulsive component in the noise emission from the activity at any noise sensitive location.

When we measure ambient noise, we effectively describe the total noise at a given position, made up from many sources. In many instances the $L_{Aeq}$ level can be significantly affected by extraneous noises, e.g., road traffic, barking dogs, etc.

Often, continuous noise emissions from an industrial source can be more readily represented by the $L_{90}$ parameter than by the $L_{eq}$. However, in this case even the $L_{90}$ parameter has been affected by wind generated noise at Position A and these measurements do not reliably describe the noise emissions from the brewery. Furthermore, changes in noise levels at Position A due to the switching on and off of equipment should not be relied upon. In many instances there was no audible noise difference whatsoever when most items of equipment were switched off. Normally this is evidence that the particular sources under investigation do not cause a noticeable or significant impact. However, due to the variation in wind generated noise, in this case it considered necessary for the measurements at Position A to be repeated during calm conditions in the early hours of the morning.

During the survey, at Position A, the most clearly audible and dominant noise sources were the Stadco Cooling Fans. There was a very noticeable reduction in the ambient noise when these were switched off. Furthermore, their likely contribution to a potential off-site impact was also determined during the on-site measurements.

While one-third octave band analysis was undertaken to investigate potential tonal noise sources, no off-site noise associated with the facility was positively identified using this analysis. Furthermore, with one exception (Stadco Cooling Fans) the noise from the brewery’s sources was not perceived to be tonal at Position A. In addition, whilst sound recordings have been made, potential tones identified on site could not be matched with audible sounds at Position A (off-site). The data have been fundamentally influenced by variations in wind speed and direction and it is considered that under calm conditions at Position A, significantly different data and findings would emerge.

It is important to note that some of the site’s sources did give rise to distinctive noise emissions and further analysis (e.g., narrow band analysis) could be undertaken to investigate definitive linkages between on-site sources and off-site sounds. This can be sometimes helpful where harmonics of certain on site noise sources become audible off site.
Despite any positive confirmation from the one-third octave band analysis, the very distinctive sound of the Stadco Cooling Fans was clearly audible at Position A. Due to the fact that it arises intermittently, it may be noticeable at a number of noise sensitive locations (NSLs), at night, as well as sounding tonal at a number of NSLs (particularly NSLs to the west of the brewery).

There are a number of conclusions which can be made from this assessment:

- All of the measurement results at Position A exceeded the night-time limit of 45 dBA. The lowest L90 value at Position A was 50 dBA and normally this can be relied upon as a reasonable descriptor of continuous industrial noise.

- Temporal variations in wind speed and direction resulted in a significant effect on the propagation of noise during the survey. Only the measurement results at Position A were significantly affected by wind-generated noise and the extent of its contribution cannot be accurately determined.

- Throughout the survey CO2 purging gave rise to intermittent noise which was likely to be clearly audible off-site. Furthermore, the purging noise is liable to be tonal off-site although this was not confirmed at the time of the assessment, due to unsuitable wind conditions. Nonetheless, the purging noise is likely to be readily simple to attenuate, although the extent of the attenuation required was not determined.

- The most obvious noise emission with an off-site impact was determined to be that arising from the Stadco Cooling Fans. This will most likely require some form of attenuation, but the weather conditions at the time of the Position A measurements preclude an accurate assessment.

Finally it is recommended that additional survey and assessment work is undertaken in order to further investigate the impact of plant noise sources. Whilst all of the on-site data can be re-used and assessed, it is important than another set of measurements at Position A is collected. This would allow the on-site and off-site recordings to be analysed by narrow-band analysis so as to definitively match the on-site noise sources with the ambient noise at Position A.

Finally, a detailed analysis of noise complaint history may be helpful in identifying and/or confirming the likely noise sources which give rise to complaints and the factors which influence them.
5. References


Figure 1: Approximate Location of off-site Noise Monitoring Position.

Photographs of off-site Noise Monitoring Position.
Figure 1 - Approximate location of off-site noise monitoring position.
APPENDIX II

Extracted monitoring results and one-third octave band analysis results.
Background noise at condenser pumps.

Note: Concentration of energy at 63 Hz

Condenser pumps operational.

Note: Increase of 20 dBA, but no tones identified using one-third OBA.
Background noise at Stadco Cooling fans.

Note: Increase of 26 dBA and tone identified at 63 Hz using one-third OBA.
Background noise at BBT Pumps.

Note: Increase of 5 dBA and no tones identified using one-third OBA.

BBT Pumps operational.

Note: Increase of 5 dBA and no tones identified using one-third OBA.
Background noise at Wort Chilling Pump.

Wort Chilling Pump operational.

Note: Increase of 13 dBA and concentration of energy at 100 Hz.
Background noise at water supply pump.

Water supply pump operational.

Note: Increase of 12 dBA and no obvious tonal noise.
Position A – All plant operating normally – Time Series.

Position A – All plant operating normally – one third OBA.
Position A – Compressors (Sabroe & Stal) off – Time Series.

Position A – Compressors (Sabroe & Stal) off – one third OBA.
Position A – Condenser pumps off – Time Series.

Position A – Condenser pumps off – one third OBA.

Position A – Stadco cooling fans off – one third OBA.
Position A – BBT pumps off – Time Series.

![Image of a time series graph showing dB levels over time.]

Position A – BBT pumps off – one third OBA.

![Image of an OBA graph showing dB levels across different frequencies.]

[Project 021 - Fast Logged]
Position A – All plant operating normally – Time Series.

Position A – All pant operating normally – one-third OBA.

Project 024 - Fast Logged

Position A – Water supply pumps off – one third OBA.

Project 024

Position A – Wort chilling pump off – one third OBA.

Position A – CO₂ & Freon compressors off – one third OBA.
Position A – All plant operating normally – Time Series.

Position A – All plant operating normally – one third OBA.
APPENDIX III

Table: Summary of Met Eireann Data
For Cork Airport

Instrumentation and External Calibration Details
External calibration of the instrumentation was undertaken by Campbell Associates. Latest certificates of calibration are attached.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Serial Number</th>
<th>Date of External Calibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrator – B&amp;K, Type 4231</td>
<td>2326589</td>
<td>24TH OF APRIL 2015</td>
</tr>
<tr>
<td>Precision Sound Analyser – B&amp;K 2250L</td>
<td>2580144</td>
<td>24TH OF APRIL 2015</td>
</tr>
</tbody>
</table>
Certificate of Calibration and Conformance

Certificate Number: U18623

Test object: Sound Level Meter, BS EN IEC 61672-1:2003 Class 1 (Precision)
Manufacturer: Brüel and Kjær
Type: 2250_4980
Serial no: 2580144

Customer: Moloney & Associates
Department: Acoustics & Environmental Consultants
Address: Greenhills House, Kilmoney, Carrigaline, Co. Cork, Ireland.
Contact Person: Mr. Dermot G Moloney - Director

Method:
Calibration has been performed as set out in CA Technical Procedures TP01 & 02 as appropriate. These are based on the procedures for periodic verification set out in BS EN IEC 61672-3:2006. Results and conformance statement are overleaf and detailed results are in the attached Test Report.

Microphone
Producer: Brüel & Kjær
Type: 4950
Serial No: 2595945
Certificate number 16621

Calibrator
Producer: Brüel and Kjær
Type: 4231
Serial No: 2320589
Certificate number U18622

Preamplifier
Producer: Brüel & Kjær
Type: ZC0032
Serial No: 6097
Included

Additional items that also have been submitted for verification
Wind shield Brüel & Kjær UA0237
Attenuator None
Extension cable None
These items have been taken into account wherever appropriate.

Environmental conditions: Pressure: 101.325 kPa Temperature: 23.0 °C Relative humidity: 50 %RH
Reference conditions: Measurement conditions: 100.47 kPa 22.4 °C 43.2 %RH

Date received: 17/04/2015
Date of calibration: 24/04/2015
Date of issue: 24/04/2015

Engineer
Patanivel Marappan B.Eng (Hons), M.Sc

Supervisor
Darren Battén Tech IOA

This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognized national standards, and to the units of measurement realized at the National Physical Laboratory or other recognized national standards laboratories. This certificate may not be reproduced other than in full, except with the prior written approval of the issuing laboratory.

Page 1 of 2
Conformance
From markings on the sound level meter or by reference to the manufacturer's published literature it has been determined that the instrument submitted for verification was originally manufactured to BS EN IEC 61672-1:2002 and similarly that the associated sound calibrator conforms to BS EN IEC 60042.

Statement of conformance
The sound level meter submitted for testing has successfully completed the class 1 periodic tests of BS EN IEC 61672-3:2006, for the environmental conditions under which the tests were performed. As public evidence was available\(^1\), from an independent testing organisation responsible for approving the results of pattern evaluation tests performed in accordance with BS EN IEC 61672-2:2003, to demonstrate that the model of sound level meter fully conformed to the requirements in BS EN IEC 61672-1:2002, and that the sound level meter submitted for testing conformed to the class 1 requirements of BS EN IEC 61672-1:2003.

\(^1\) This evidence is held on file at the calibration laboratory.

Measurement Results:
- Indication at the calibration check frequency - IEC 61672-3 Ed 1 #9: Passed
- Self-generated noise - IEC 61672-3 #10: Passed
- Acoustical test of a frequency weighting - IEC 61672-3 Ed 1 #11: Passed
- Frequency weightings: A Network - IEC 61672-3 Ed 1 #12: Passed
- Frequency weightings: C Network - IEC 61672-3 Ed 1 #12: Passed
- Frequency weightings: Z Network - IEC 61672-3 Ed 1 #12: Passed
- Frequency and time weightings at 1 kHz: IEC 61672-3 Ed 1 #13: Passed
- Level linearity on the reference level range - IEC 61672-3 #14: Passed
- Toneburst response - IEC 61672-3 Ed 1 #16: Passed
- Peak C sound level - IEC 61672-3 Ed 1 #17: Passed
- Overload indication - IEC 61672-3 Ed 1 #18: Passed
- Combined electrical and acoustical test - IEC 61672-3 Ed 1 #12: Passed

Comment
Correct level with associated calibrator is 93.9dB(A).

Observations
The details of the uncertainty for each measurement is available from the Calibration Laboratory on request and is based on the standard uncertainty multiplied by a coverage factor \(K=2\), providing a level of confidence of approximately 95%. The uncertainty evaluation has been carried out in accordance with UKAS requirements. Details on the sources of corrections and their associated uncertainties that relate to this verification are contained in the detailed test report accompanying this certificate.
Certificate number: U18622

Certificate of Calibration and Conformance

Test object: Sound Calibrator
Manufacturer: Briel and Kjær
Type: 4231
Serial no: 2326589

Customer: Moloney & Associates
Department: Acoustic & Environmental Consultants
Address: Greenshills House, Kilmoney, Carrigaline, Co. Cork, Ireland.
Contact Person: Mr. Dermot O'Moloney - Director

Measurement Results:

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>Stability</th>
<th>Frequency</th>
<th>Stability</th>
<th>Distortion</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>94.02 dB</td>
<td>0.01 dB</td>
<td>999.99 Hz</td>
<td>0.00 %</td>
<td>0.35 %</td>
</tr>
<tr>
<td></td>
<td>94.02 dB</td>
<td>0.01 dB</td>
<td>999.99 Hz</td>
<td>0.00 %</td>
<td>0.35 %</td>
</tr>
<tr>
<td></td>
<td>94.02 dB</td>
<td>0.01 dB</td>
<td>999.99 Hz</td>
<td>0.00 %</td>
<td>0.35 %</td>
</tr>
</tbody>
</table>

Result (Average):

|                | 94.02 dB | 0.01 dB | 999.99 Hz | 0.00 %   | 0.35 %     |

Expanded Uncertainty:

|                | 0.10 dB | 0.02 dB | 1.00 Hz | 0.01 % | 0.10 %     |

Degree of Freedom: >100
Coverage Factor: 2.00

The stated level is relative to 20µPa. The level is traceable to National Standards.
The stated level is valid at reference conditions. The following correction factors have been applied during the measurement:
Pressure: 0.00005 dB/kPa  Temperature: 0.0015 dB/°C  Relative humidity: 0.001 dB/%RH  Load volume: 0.0003 dB/mm3
The reported expanded uncertainty of measurements is based on a standard uncertainty multiplied by the coverage factor of k=2, providing a level of confidence of approximately 95%. Where the degrees of freedom are insufficient to maintain this confidence level, the coverage factor is increased to maintain this confidence level. The uncertainty has been determined in accordance with UKAS requirements.

Records: KXC AOCalibrationNor-16DNor-1016 CalCat2016UKNIK4231v1_2326589_M1.nnn

Environmental conditions:

<table>
<thead>
<tr>
<th></th>
<th>Pressure</th>
<th>Temperature</th>
<th>Relative humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference conditions</td>
<td>101.325 kPa</td>
<td>23.0 °C</td>
<td>50 %RH</td>
</tr>
<tr>
<td>Measurement conditions</td>
<td>100.569 ± 0.842 kPa</td>
<td>21.6 ± 0.2 °C</td>
<td>42.0 ± 2.1 %RH</td>
</tr>
</tbody>
</table>

Date received for calibration: 17/04/2015
Date of calibration: 24/04/2015
Date of issue: 24/04/2015
Engineer

Supervisor

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This certificate is issued in accordance with the laboratory accreditation requirements of the United Kingdom Accreditation Service. It provides traceability of measurement to recognised national standards, and to the units of measurement realised at the National Physical Laboratory or other recognised national standards laboratories. This certificate may not be reproduced other than in full without the prior written approval of the issuing laboratory.
The equipment was preconditioned for more than 4 hours in the specified calibration environment.

Measurements
The calibrator has been tested as described in the following annexes to BS EN IEC60942:2003 Sound Calibrators; B3.4 for sound pressure level, B3.5 for frequency, B3.6 for total distortion and A4.4 for short term stability of the pressure level.

Method
Calibration has been performed as set out in the current version of CA Technical procedure TP01

Instruments and program
A complete list of equipment, hardware and software that has been used in this calibration is available from the calibration laboratory on request.

Traceability
The measured values are traceable to the following laboratories:
Sound Pressure Level: National Physical Laboratory, United Kingdom
Voltage: National Physical Laboratory, United Kingdom
Frequency: National Physical Laboratory, United Kingdom
Ambient Pressure: National Physical Laboratory, United Kingdom
Temperature & Relative Humidity: National Physical Laboratory, United Kingdom

Comment
Primary level used as default. Secondary level = 114.05dB. Note this is not UKAS data.

Statement of conformance
As public evidence was available, from a testing organisation responsible for approving the results of pattern evaluation tests, to demonstrate that the model of sound calibrator fully conformed to the requirements for pattern evaluation described in annex A of BS EN IEC 60942:2003, the sound calibrator tested is considered to conform to all the class 1 requirements of that BS EN IEC 60942:2003.

Notes:
The sound pressure level generated by the calibrator in its ¼ inch configuration was measured five times and averaged by a WS2P working standard microphone for class 1 or 2 devices or a LS2P reference microphone for class 0 or LS devices as specified in the International Standard BS EN 01094-4. The results of three replications and the mean of the measurements obtained are given in the measurement results table of this certificate. The frequency and distortion were measured in a similar manner. The figures in BOLD are the final results, a small correction factor may need to be added to the sound pressure level quoted here if the device is used to calibrate a sound level meter that is fitted with a free field response microphone. See manufacturer's handbooks for full details of this and other corrections that may be applicable.
APPENDIX IV

Glossary
**Glossary:**

**1/3 (one-third) Octave Band Analysis:**
Frequency analysis of sound such that the frequency spectrum is subdivided into bands of one–third of an octave each. An octave is taken to be a frequency interval, the upper limit of which is twice the lower limit (the unit of frequency is the Hertz, Hz).

**Ambient Noise:**
The totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, near and far.

**Audible:**
Sound that can be heard or is perceptible to the human ear.

**Background Noise Level:**
The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 per cent of a given time interval, T. (L_{A90, T}).

**Criterion Noise Level:**
The long-term mean value of the noise level that must not be exceeded. This is generally stipulated in an IPPC or Waste Licence and it may be applied to a noise source, a boundary of the activity or to noise sensitive locations in the vicinity of the facility.

**Daytime:**
08:00 hrs to 22:00 hrs (night-time is regarded as the period: 22:00 hrs to 08:00 hrs).

**dB (decibel):**
The scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the RMS pressure of the sound field and the reference pressure of 20 micro-pascals (20 μPa).

**dBA or dB(A):**
An ‘A-weighted decibel’ - a measure of the overall noise level of sound across the audible frequency range (20 Hz – 20 kHz) with A-frequency weighting (i.e. ‘A’–weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.

The A-weighting network, weights a sound pressure level in such a manner that it approximates to how we hear sound. Table A4.1 helps to illustrate how various A-weighted decibel levels might sound, in practice.

<table>
<thead>
<tr>
<th>Decibel Reading dB(A)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Absolute silence</td>
</tr>
<tr>
<td>25</td>
<td>Very quiet room</td>
</tr>
<tr>
<td>35</td>
<td>Rural night-time setting. No wind.</td>
</tr>
<tr>
<td>55</td>
<td>Day-time, busy roadway 0.5 Km away</td>
</tr>
<tr>
<td>70</td>
<td>Busy restaurant</td>
</tr>
<tr>
<td>85</td>
<td>Very busy pub. Voice has to be raised to be heard</td>
</tr>
<tr>
<td>100</td>
<td>Disco or rock concert</td>
</tr>
<tr>
<td>120</td>
<td>Uncomfortably loud. Conversation impossible</td>
</tr>
<tr>
<td>140</td>
<td>Noise causes pain in ears.</td>
</tr>
</tbody>
</table>
Facade Level:
Noise levels at locations 1m from the facade of a building are described by the term *Facade Levels* and are subject to higher noise levels than those in open areas (free-field conditions) due to reflection effects.

Free-field measurements:
Noise measurements made at a sufficient distance from acoustically reflective surfaces, other than the ground such that acoustic reflections from these surfaces do not significantly contribute to the measured noise level. Such measurements are also called non-façade measurements.

Impulse Exponential – Time-Weighting:
This is a time-weighting which is available on some sound level meters and it represents an arbitrary compromise in an attempt to provide a means to measure the sound level of short-duration impulsive sounds. Impulse time-weighting has a design goal exponential-time constant of 35 ms for sound signals that increase with increasing time and 1.5 seconds for sound signals that decrease with increasing time.

Impulsive Noise:
A noise that is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background. In determining whether a tonal adjustment applies, reference can be made to ISO 1996-2 (1987) - Section 4.1.

Inaudible:
Sound that cannot be heard or is imperceptible to the human ear.

$L_{Aeq,T}$:
The equivalent steady sound level in dB containing the same acoustic energy as the actual fluctuating sound level over the given period, $T$.

Noise:
Any sound, that has the potential to cause disturbance, discomfort or psychological stress to a subject exposed to it, or any sound, that could cause actual physiological harm to a subject exposed to it, or physical damage to any structure exposed to it, is known as noise.

Noise Sensitive Location:
Any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.

Rating level ($L_{Ar,T}$):
The specific noise level, plus any adjustment for the characteristic features of the noise.

Root Mean Square (RMS):
The RMS value of a set of numbers is the square root of the average of their squares.

Time-weighting:
One of the averaging times (Fast, Slow or Impulse) used for the measurement of RMS sound pressure level in sound level meters.

Tonal Noise:
Noise which contains a clearly audible tone, i.e. a distinguishable, discrete or continuous note (whine, hiss, screech or hum etc.)