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Acoustic Impact Assessment of Proposed Air Source Heat Pump at:

21 Barton Road
Haslingfield
Cambridge
Cambridgeshire
CB23 1LL

for:

Clare Sheehan

Report Reference: B5632 2024-02-14 R ASHP

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Contents

1.0 Synopsis

1.1 Acoustical Control Consultants (ACC) have been appointed to conduct an acoustic assessment of the Air Source Heat Pump (ASHP) installed at 21 Barton Road, Haslingfield.

1.2 As part of the assessment, an acoustic survey was undertaken to gather representative sound level measurements and associated data regarding the acoustic environment at the time it is proposed to operate the ASHP i.e. around 5 to 6pm..

1.3 The rating level of sound from the ASHP is 33 dB L_{Ar} outside the neighbouring dwelling's most noise sensitive window. The background sound level at the proposed operating time of late afternoon/ early evening is around 35 dB $L_{A90,1hour}$. This means that the rating level is approximately 2 dB lower than the background sound level.

1.4 ACC has established sound level criteria based on the relevant local and national guidance relating to fixed plant and equipment at a site such as this. The derived criteria consider both the level and character of sound required to protect amenity according to relevant guidance.

1.5 The sound level emitted by the ASHP complies with all identified criteria intended to protect the amenity of neighbouring residents so there is no reason why the application should be refused on acoustic grounds.

2.0 Introduction

2.1 Acoustical Control Consultants (ACC) has been appointed by Clare Sheehan to undertake an acoustic assessment of the Air Source Heat Pump (ASHP) which has been installed and is operational at 21 Barton Road, Haslingfield, to support the planning application that has been found to be necessary for this installation.

2.2 It is necessary to ensure that that the ASHP will be able to operate efficiently, with suitable sound levels to protect the amenity of the closest noise sensitive receptors.

2.3 This assessment follows the principles of BS 4142:2014 +A1:2019 Methods for rating and assessing industrial and commercial sound. This report provides details of the site survey and subsequent qualitative and quantitative analyses of the data.

2.4 ACC is an independent acoustic consultancy company. All our acoustic consultants are qualified and experienced practitioners and are either Associate or Corporate members of the Institute of Acoustics. Acoustical Control Engineers Limited is our associated company specialising in engineered solutions to acoustic problems.

3.0 Scope

3.1 Undertake and preliminary survey, review available data, and provide preliminary advice, subject to the findings of the subsequent acoustic survey, analysis and assessment.

3.2 Undertake a fully attended acoustic survey to gather data on the acoustic environment at the closest receptors to the ASHP with the plant operating and the residual environment when the plant is not operating.

3.3 Analyse the data and compile an assessment report based on BS 4142, showing the results of the survey, associated analysis of the data, and assessment of the acoustic impact of the ASHP.

4.0 Equipment to be Assessed

4.1 The ASHP is a Daikin Altherma 3M EDLA14DA3V3 unit. It is situated beside 21 Barton Road in the gap of approximately 2.5 m width between the buildings of 21 & 23 Barton Road. the unit is set back approximately 7 m from the front façades of the dwellings and is approximately 10 m in front of the dwellings' rear facades. The fence between the dwellings is approximately 1.8 m tall, comprising overlapped feather edged boards, with small gaps at the posts. It may provide a small amount of acoustic screening to neighbouring ground floor level receptors.

4.2 Acoustically, the unit's significant components are the compressor and fan, both of which operate at variable speed, depending on the thermal load. The unit typically operates for one period each day, extracting heat from the air and using this to heat a hot water store indoors, that is used to provide heating throughout the day & night. When operating the unit's mobile phone app shows the electrical power being used, which provides a reliable indication of the unit's operating capacity. The maximum load equates to around 4 kW. It is understood that in particularly cold conditions the unit may briefly operate in defrost mode during the night, but under these cold conditions it is less likely that bedroom windows will be open.

4.3 If the unit operates at night, the cost of electricity is lower, but the residual sound level is lower, than during the day and the acoustic sensitivity of neighbouring dwellings is greater. Conversely, if the unit is set to operate during the day, then the higher residual sound level provides greater masking to sound from the unit, and neighbouring dwellings are less sensitive to noise than during the night.

4.4 Figure 1 shows the location of the ASHP relative to the two dwellings.

Figure 1 ASHP Location on site

5.0 Relevant Guidance & Criteria

5.1 Annex B provides a detailed review of relevant guidance that may be applicable to this assessment. The key points of each relevant document are summarised below:

Noise Policy Statement for England (NPSE) March 2010

5.2 The Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy by promoting good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development. It provides an often previously missed 'opportunity for the cost effective management of noise'.

5.3 This applies three concepts to assess noise impact:

5.4 No Observed Effect Level (NOEL) which is the level below which no effect can be detected.

5.5 Lowest Observed Adverse Effect Level (LOAEL) which is the level above which adverse effects on health and quality of life can be detected.

5.6 Significant Observed Adverse Effect Level (SOAEL) which is the level above which significant adverse effects on health and quality of life occur.

5.7 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development.

5.8 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur.

5.9 These make it clear that noise must not be considered in isolation but as part of the overall sustainability and associated impacts of the proposed development. There is no benefit in reducing noise to an excessively low level, particularly if this creates or increases some other adverse impact.

5.10 NPSE clarifies the difference between NOEL and LOAEL as used in Night Noise Guidelines for Europe, which gives values of 30 dBA and 40 dBA for the night time average level measured outside dwellings respectively. This indicates that there may be no significant overall benefit in achieving an average level of less than around 40dBA outside dwellings during the night.

National Planning Practice Guidance – Noise (NPPG) July 2019

5.11 This document 'advises on how planning can manage potential noise impacts in new development'.

5.12 Below the 'lowest observed adverse effect level' (LOAEL) 'the noise may slightly affect the acoustic character of an area but not to the extent there is a change in quality of life. If the noise exposure is at this level no specific measures are required to manage the acoustic environment'.

5.13 Above the 'significant observed adverse effect level' (SOAEL) 'the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present. If the exposure is predicted to be above this level the planning process should be used to avoid this effect occurring, for example through the choice of sites at the plan-making stage, or by use of appropriate mitigation such as by altering the design and layout'.

5.14 Between the LOAEL and SOAEL 'the noise starts to cause small changes in behaviour and attitude, for example, having to turn up the volume on the television or needing to speak more loudly to be heard. The noise therefore starts to have an adverse effect and consideration needs to be given to mitigating and minimising those effects (taking account of the economic and social benefits being derived from the activity causing the noise)'.

BS 4142:2014 + A1:2019 Methods for rating industrial and commercial sound

5.15 BS 4142 is the primary standard for the assessment of the impact of plant sound on residential receptors. The BS 4142 methodology primarily compares the rating level (average source noise level with a suitable character correction if applicable), against the existing background level (that exceeded for 90% of the time i.e. the quietest 10% level) and provides an indication of the likelihood of adverse impact based solely upon this differential.

Rating level - Background sound level	Initial Estimate
Around 10 dB or more	Likely to be an indication of a significant adverse impact, depending on the context.
Around 5 dB	Likely to be an indication of an adverse impact, depending on the context.
Similar levels	An indication of the specific sound source having a low impact, depending on the context.

5.16 One of the significant differences between BS 4142:2014 and previous editions of the Standard is the explicit requirement to consider context as part of the assessment. It is no longer adequate to simply compare the rating level and the background sound level without due regard to the context of the acoustic environment and the sound source. The context can significantly affect the outcome of the Initial Estimate, which is based solely on the difference between the rating and background sound levels. The background sound level (L_{A90}) specifically excludes acoustic events occurring for less than 90% of the time, such as passing vehicles or activity occurring for much but not all of the time. This means that the difference between rating and background sound levels can be identical for two locations with very different acoustic characteristics and corresponding sensitivities to noise.

5.17 In addition to comparing the level and character of the specific and residual sound, the context also includes careful consideration of other factors such as the character of the locale e.g. quiet rural or predominantly industrial; noise sensitive receptors e.g. outdoor amenity space or indoors; and duration and time of specific sound e.g. 24/7 operation or one event per week.

5.18 Depending upon the context, other guidance may be more appropriate, such as considering the potential impact of sound on residents during the night when the primary concern is to ensure that they are not disturbed whilst sleeping, possibly with open bedroom windows. In this case the difference between background sound level and rating level outdoors is likely to be of little significance to the residents indoors and other guidance such as BS 8233 is more relevant.

BS 8233:2014 Guidance on sound insulation and noise reduction for buildings

5.19 For dwellings the main considerations are to protect sleep in bedrooms and to protect resting, listening and communicating in other rooms. For noise without a specific character it is desirable that the overall average levels during the night or day time periods do not exceed 30 dB $L_{Aeq,8hour}$ or 35 dB $L_{Aeq,16hour}$ respectively.

5.20 For amenity space, such as gardens and patios, it is desirable that the average level does not exceed 50 dB L_{Aeq}, with an upper guideline value of 55 dB L_{Aeq} which would be acceptable in noisier environments. For dwellings with conventional windows, an internal target of 35 dB L_{Aeq} during the day equates to around 50 dB L_{Aeq} (possibly slightly lower) outside noise sensitive rooms with openable windows.

World Health Organization: Guidelines for Community Noise & Night Noise Guidelines for Europe

5.21 These establish that a steady level of 30 dB L_A within bedrooms is suitable to protect vulnerable people from sleep disturbance and that occasional maximum levels of up to around 42 dB L_{Amax} to 45 dB L_{Amax} are also consistent with this. The difference between a sound level outdoors and the resultant level indoors with open windows varies through Europe due to differing building characteristics and particularly window type. An average difference of around 15 dB L_A is often used, although this is also dependent upon other factors such as the frequency spectrum of the incident sound.

Chartered Institution of Building Services Engineers: CIBSE Guide A: Environmental Design

5.22 The environmental design guidance provides details of Noise Rating (NR) curves which are commonly used within Europe for specifying mechanical plant in order to control the character of the noise. The relationship between NR and dBA is not constant because it depends upon the spectral characteristics of the noise. However, for ordinary intrusive noise found in buildings, dB L_A is usually between 4 and 8 greater than the corresponding NR level. BS 8233 gives a single conversion value of 6.

5.23 Table 1.15 of the design guidance provides a suggested maximum noise level generated within urban dwellings of NR25 for bedrooms and NR30 for living rooms. Guidance is also provided for offices and public buildings.

MCS 020

5.24 This document provides guidance to facilitate the use of ASHPs so that, if an installation complies with the MCS 020 and other relevant criteria, there is no need to obtain planning permission for the plant.

5.25 An analysis of the document shows that it sets an upper limit of 37 dB L_A to the sound pressure level produced by the ASHP, 1 m outside any neighbouring dwelling's habitable rooms.

5.26 It is understood that this installation does not comply with the MCS 020 criteria in other respects so that method is not applicable in this case.

Local Authority Specific Guidance

5.27 A South Cambridgeshire District Council planning consultation response memo dated 17/10/2023 states that:

> If the ASHP rating noise level (as discussed above) including character corrections / reflections etc is below a predicted background sound level likely to be representative of the application site area during the late evening / night of 35 dB, a full noise impact assessment may not be required.

5.28 This is consistent with the local authority's intention that sound from the ASHP should not exceed the background sound level at the neighbouring dwellings noise sensitive locations. Whilst this approach does not fully consider the context in which the sound will be experienced, as required by BS 4142, it does provide a starting point for assessment.

Summary and Discussion

5.29 Table 5.1 below summarises the recommendations of all current authoritative guidance.

Results	Daytime
BS 8233:2014 guidance	35 dB L_A cumulative indoors equating to 45 dB L_A outside the windows of internal receptors
NPSE guidance	
World Health Organization	35 dB L_A cumulative indoors equating to 45 dB L_A outside the windows of internal receptors
Local Authority guidance	An acoustic assessment may not be required if the ASHP's rating level does not exceed 35 dB L_{AR} at noise sensitive locations.

Table 5.1 Summary of guidance

5.30 The assessment methodology will therefore start with an Initial Estimate of the Likely Significance of the Impact based on the BS 4142 methodology of determining the difference between the rating levels based on the sound emissions from the ASHP and background sound levels obtained by a survey of the site. This Initial Estimate must then be reviewed within the context in which the sound from the ASHP is experienced by neighbouring residents, including the absolute sound levels involved, the acoustic nature of the area around the site and the guidance of the other documents described above.

6.0 Acoustic Environment

6.1 21 Barton Road is situated in Haslingfield approximately 4 km southwest of the closest outskirts of Cambridge. At its closest, the M11 motorway is approximately 3 km in the same direction and the A10 trunk road approaches to within approximately 2.5 km to the southeast. The London – Cambridge railway line is approximately 3 km in the same direction. The A603 between Royston and Cambridge passes approximately 2 km to the northwest. There is also a quarry approximately 1 km to the southwest but this is understood to be disused and acoustically insignificant. Figure 2, below, shows these key features relative to Haslingfield.

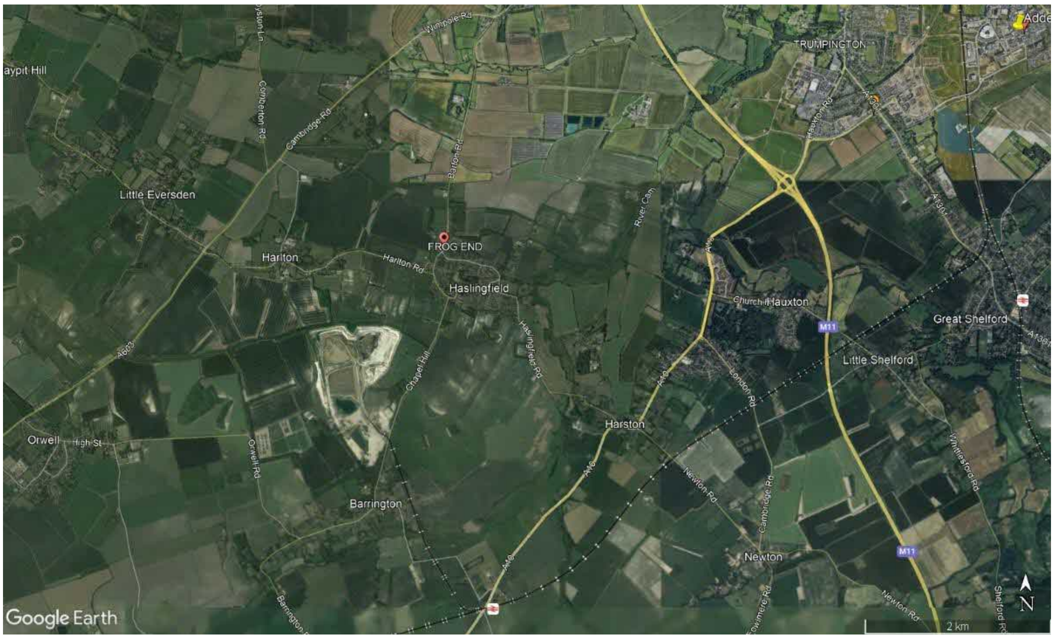


Figure 2 Location of 21 Barton Road & Haslingfield

6.2 Barton Road connects Haslingfield with the A603 to the north, providing a connection with both Cambridge and via the M11, elsewhere. This means that a significant amount of traffic uses Barton Road, particularly during the morning and evening 'rush hour' periods.

6.3 The main parts of the buildings of 21 and 23 Barton Road are set back approximately 17 m from Barton Road itself which provides some 'distance attenuation' to the sound from vehicles passing immediately in front of these dwellings. The buildings themselves provide the rear of the properties with acoustic screening attenuation from this road traffic, which means that the resultant sound levels to the rear of the dwellings are somewhat lower than those to the front. Figure 3 below shows the location of 21 Barton Road, with 23 immediately to the north.

Figure 3 Relative location of 21 & 23 Barton Road

6.4 As the ASHP is located between the two dwellings, sound propagates away from the unit upwards and towards the front and rear of the dwellings. The resultant sound in the area between the dwellings is relatively constant because aside from negligible absorption by nearby surfaces such as brick walls, the only paths for sound to reduce are the components that exit the area upwards or to the front and rear of the buildings. This means that the sound level from the ASHP is highest in the area between the dwellings and somewhat lower at the front and rear of the buildings.

6.5 Condition 3 of planning decision reference S/1048/95/F which granted consent for the construction of 23 Barton Road states:

> The first floor windows shall be non-opening, fixed and be fitted and permanently maintained with obscured glass to Plot 1, Bedroom 1 in the south elevation of the building hereby permitted.

6.6 The sound level inside a building due to ingress of sound outside the building is usually controlled by the amount of sound entering the building through the windows. A window that is partly open for ventilation purposes will typically provide around 10 to 15 dB LA difference between the sound level outside the building and that indoors. A closed window can be estimated to provide circa 15 dB more attenuation than an open window.

6.7 The sound level from the ASHP is higher outside the neighbouring dwelling's southern bedroom window, which overlooks the ASHP, than outside windows to the front of rear of the dwelling, because sound from the ASHP has to diffract (bend) around the vertical edge of the building to reach these other windows.

6.8 However, the southern bedroom window is less sensitive to noise from the ASHP than windows to the front or rear of the dwelling because it cannot be opened and the additional attenuation provided by a closed window is similar to or greater than the reduction in sound level to windows at the front or rear of 23 Barton Road.

6.9 Because the area to the rear of the dwellings is acoustically sheltered from road traffic noise, this means that the most noise sensitive windows are to the rear of the property. Similarly, the outdoor amenity area to the rear of the dwelling is more noise sensitive than the front of the property.

7.0 Surveys

7.1 A preliminary visit was carried out by Richard A Collman BSc (Jt. Hons), CEng, MIOA, Tech IOSH during the late afternoon of Friday 24th November. The purpose of this visit was to gain an initial understanding of the current situation and acoustic environment where the ASHP is located to inform preparations for the acoustic survey.

7.2 From information gathered during this visit it was concluded that any acoustic impact from the ASHP would be minimised if the unit operates during a busier time of the day, when the residual sound level is higher and therefore provides more masking to sound from the unit. As previously noted, the day is also less noise sensitive than the night.

7.3 A fully attended site visit and acoustic survey were then carried out also by Richard Collman during the early evening of Monday 29th January 2024 between17:50 and 19:00. One purpose was to gather representative measurements of the acoustic environment at the most sensitive receptors with the plant operating and without (residual sound level). These measurements were made at a height of 1.5 m above ground level and approximately 3.5 m away from reflective surfaces apart from the ground.

7.4 Further measurements were made adjacent to the ASHP in order to provide data for comparison with the manufacturer's stated sound levels.

Instrumentation

Rion 1/3 Octave Band Analyser Type NA-28, Serial No. 01070575
Rion Sound Calibrator Type NC-74, Serial No. 34246504
Rion Windshield
Tripod
Skywatch Meteos Anemometer

7.5 Operational reference checks were undertaken before and after the measurements using the calibrator. The instrument displayed negligible drift in calibration. In addition to the on-site operational check, the instrumentation holds valid calibration certificates which are available upon request.

Weather Conditions

7.6 Weather conditions were observed and noted throughout the survey. There was an approximately southerly breeze of around 1 – 4 m/s, the temperature was around 11°C, the sky was overcast and ground surfaces were dry. The local weather conditions at the time of the survey were within the limits set out in the guidance and appropriate for the measurements to be taken.

7.7 As explained more fully in Annex A, the ambient sound level is dependent upon the prevailing weather conditions. Under differing weather conditions, it is expected that the residual sound level may be somewhat higher or lower due to the variation in contribution from more distant sources.

Measurements

7.8 Annex A reviews factors that affect the background sound level, which varies depending upon many factors, rather than being a single value as the name may suggest. The synopsis summarises the factors considered when determining the most appropriate timing, duration and method for the acoustic survey.

7.9 The measured background sound level is what was measured at the time and under the weather conditions prevailing during the survey. This is used for the acoustic assessment, but consideration should also be given to the uncertainty that may be introduced in the outcome of the assessment due to the variation in background sound level at different times or under different weather conditions.

7.10 The measurement technique used for this survey involves logging the sound level many times each second and recording relevant observations of factors contributing to the acoustic environment at this time. This technique provides a substantial amount of data regarding the acoustic environment and informs consideration of the effects of uncertainty. In the case of the residual sound level, approximately 36,000 sound level measurements were obtained per hour of measurements and are shown graphically to enable the character of the acoustic environment to be better understood.

7.11 These measurements show the level and variability of the residual acoustic environment at the time of the survey. The fully attended survey provides a far better understanding of the factors that affect the measured sound level than is possible with an unattended survey. Even if an unattended survey is for a prolonged period, the uncertainty regarding the measurement conditions and how this affected the measured levels remains. It is also likely that an unattended survey over a few days will record the residual sound level under relatively similar conditions and it is usually not practicable to gather data over a much longer period that includes seasonal variation and a much wider range of weather conditions. Annex A provides further detail, explaining why a relatively short duration fully attended survey provides better quality data that, together with an appropriate consideration of uncertainty, appropriately informs the subsequent assessment of the data.

Results - Background and Residual Sound levels

7.12 In BS 4142 the terms background sound level, ambient sound level and residual sound level have specific meanings as follows:

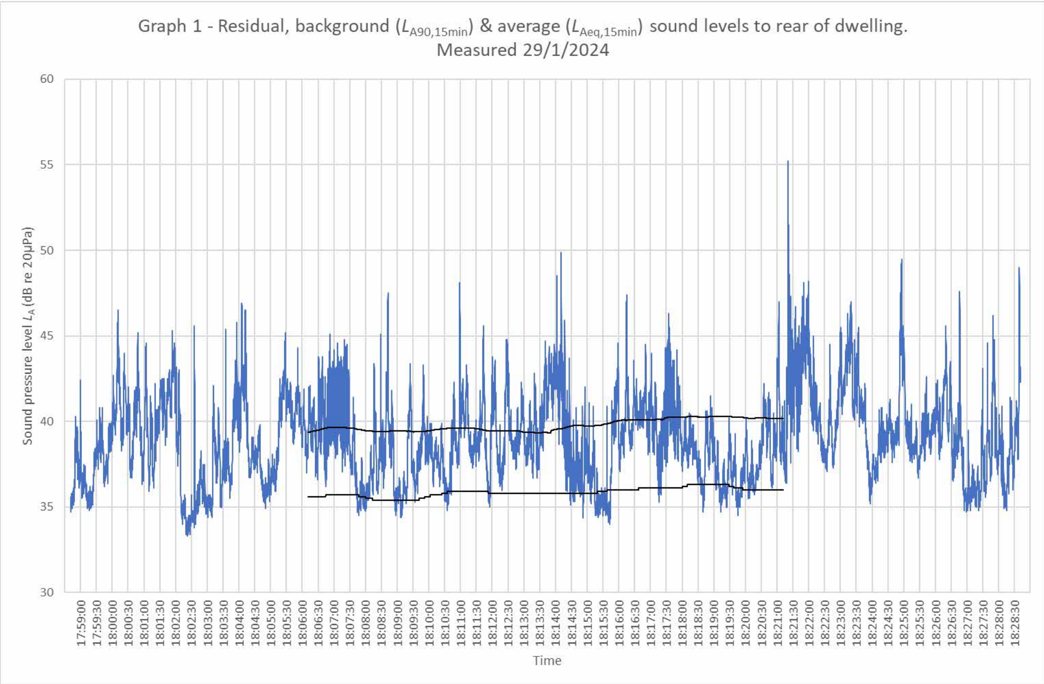
Background sound level, $L_{AF90,T}$ dB - defined in the standard as the A-weighted sound pressure level that is exceeded by the residual sound for 90% of a given time interval T, quoted to the nearest whole number of decibels'.

Ambient sound level, $L_{Aeq,T}$ dB - defined in the standard as the totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far when present. The ambient sound can comprise the residual sound and the specific sound from the source being assessed.

Residual sound level, $L_r = L_{Aeq,T}$ - the ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient Sound'.

7.13 One aim of the survey was to establish representative residual (average) and background (quietest 10%) sound levels in the vicinity of the most sensitive areas.

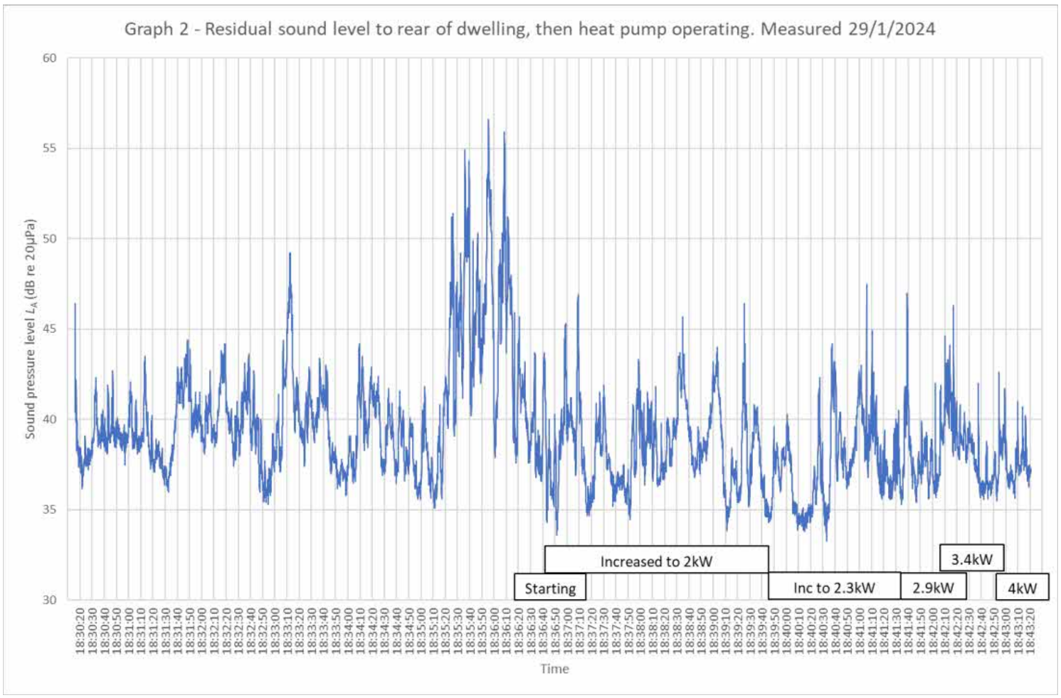
7.14 Graph 1 shows the residual (ASHP inoperative) sound level measurements made to the rear of 21 Barton Road approximately 2.5m across the rear of the house from the gap between the two dwellings. This location was selected as being acoustically equivalent to the most noise sensitive bedroom window of 23 Barton Road.



7.15 The main sources of sound at this location were road traffic, occasional aircraft, occasional movement of foliage etc., and some animals. The sound level typically varied around 35 to 45 dB L_A, rising occasionally typically up to 50 dB L_A. The peak of 55 dB L_A was due to a nearby unidentified animal.

7.16 The black lines show the rolling average and background sound levels, the former of which varied between 39 and 40 dB $L_{Aeq,15min}$ and the latter between 35 and 36 dB $L_{A90,15min}$. This indicates that, if the ASHP is set to operate at around this time each day it is appropriate to use a residual sound level of 39 dB $L_{Aeq,1hour}$ and a background sound level of 35 dB $L_{A90,1hour}$ for BS 4142 assessment purposes in order to establish an Initial Estimate of the Likely Significance of Impact, which must then be reviewed in order to take account of the context in which the sound from the ASHP will be experienced.

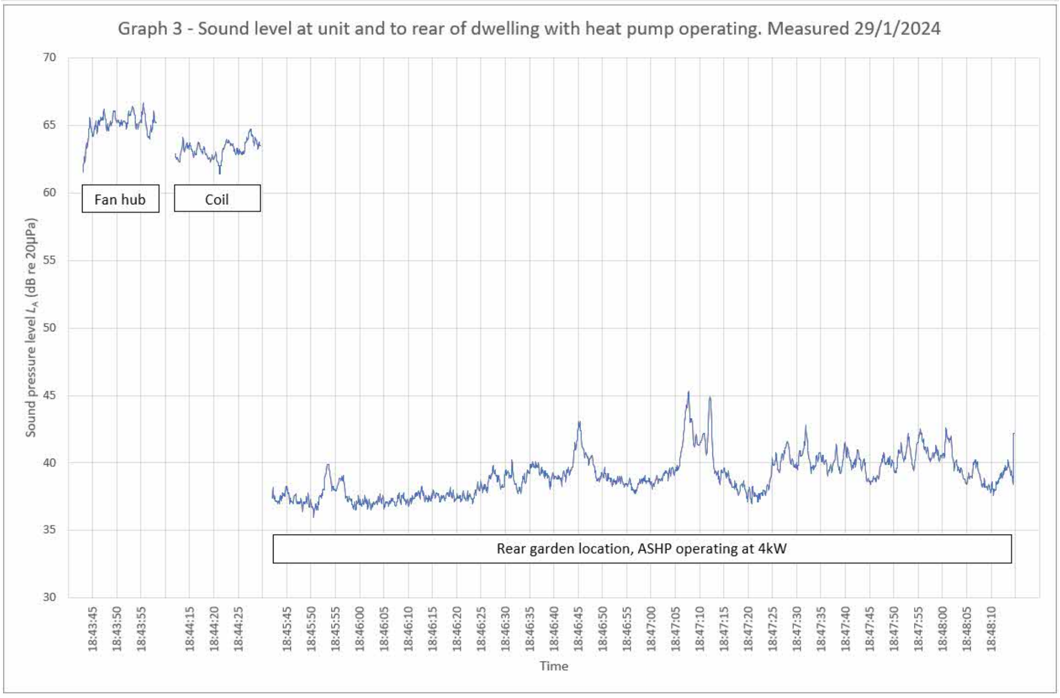
7.17 Graph 2 shows the ambient sound level measurements made at the same location whilst the ASHP was switched on and increased its operational speed and load. The unit started operating at about 18:36:19 so the underlying sound level before then was about 35 dB L_A, which is slightly higher than the measurements shown in Graph 1.



7.18 When the unit was operating around full capacity (4 kW) the underlying sound level was around 36 dB L_A.

7.19 Whilst the unit was operating at full capacity the sound level was measured adjacent to the unit's discharge fan and also the air inlet coil. The latter measurement was made close to the coil between the coil and nearby wall. This means that this measured sound level also includes sound reflected between the wall and coil so is higher than would be the case if the sound level from the coil was measured in 'free field' conditions.

7.20 A further series of measurements was then made at the original measurement location to the rear of 21 Barton Road to check for consistency with the measurements shown in Graph 2.



7.21 Graph 3 shows that the sound level at the fan hub was around 65 dB L_A and by the coil it was around 63 dB L_A. The underlying sound level to the rear of 21 Barton Road fell to around 36 dB L_A when the unit was operating at full capacity.

8.0 Analysis

8.1 Lines 1 to 3 of Calculation Sheet 1 at Appendix 2 calculate the specific level (sound level due to the ASHP in the absence of other 'residual' sound) at the measurement location to be 32 dB L_A. This conservatively assumes the residual level to be a low level of 34 dB L_A. If the residual level is slightly higher than this the calculated specific level will be somewhat lower, so this sets an upper limit of around 32 dB L_A on the specific level produced by the ASHP. The measurement location is a good proxy for the specific level outside the rear bedroom window of 23 Barton Road. For ground floor locations, which should be considered to be the noise sensitive receptors if the ASHP operates during the day (i.e. between 07:00 and 23:00) the specific level will be slightly lower due to acoustic screening attenuation provided by the intervening fence. Therefore, this indicates that around 32 dB L_A is a realistic upper limit to the specific level produced by the ASHP at noise sensitive locations around 23 Barton Road.

8.2 Lines 4 to 7 provide a basic BS 4142 comparison between the ASHPs rating level and the background sound level at this time of the day, giving a difference of -3 dB. BS 4142 states that:

> The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

8.3 Lines 8 to 11 provide a verification of the specific level calculated from the measurements, using the manufacturer's stated sound power level instead. This independent method gives a calculated specific level of 33 dB L_A, which is consistent with the previous calculated level of 32 dB L_A.

8.4 Lines 12 to 19 provide an analysis of the ASHPs sound power level based on indicative on site measurements, for comparison with the manufacturer's stated sound power level of 62 dB L_{WA}. This method gives a sound power level of 63 dB L_{WA} which is consistent with the manufacturer's data.

8.5 To summarise the findings of these analyses, there is a high degree of confidence that the specific level due to the ASHP is 33 dB L_A or lower at noise sensitive locations of 23 Barton Road.

9.0 Assessment

Suitable Plant Sound Criteria

9.1 MCS 020 indicates that, if the installation complies with relevant criteria, a suitable sound level will be up to 37 dB L_A outside (openable) windows of 23 Barton Road's habitable rooms.

9.2 The local authority has indicated that if the sound level does not exceed 35 dB L_A then an acoustic assessment may not be required. This does not set an upper limit of 35 dB because an acoustic assessment may show that a higher level is also suitable.

9.3 BS 4142 indicates that, depending on the context, a rating level similar to the background sound level of around 35 dB may have low impact.

9.4 If sound from the ASHP is similar to the background sound level then residual sound will tend to mask that from the ASHP which means that no character correction is required its specific and rating levels will be the same.

9.5 Therefore, a good starting point for a highest suitable level is a rating level of 35 dB L_A at noise sensitive locations, below which it can be assumed that sound from the ASHP will be suitable and above which further assessment will be required.

ASHP Sound Level

9.6 Line 3 of Calculation Sheet 1 shows the ASHP's specific level to be around 32 dB L_A at noise sensitive locations. Line 11 is consistent with this, arriving at a specific level of 33 dB L_A using manufacturer's data rather than on site measurements.

9.7 Therefore, it is appropriate to use a conservative specific level of 33 dB L_A for the ASHP, which errs on the high side, for assessment purposes.

Character correction

9.8 When applying a character correction, it is the significance or otherwise of the characteristics of the source sound at the noise receptor location that must be considered. For example, sound from the source may appear highly impulsive when standing next to it, particularly under 'laboratory' conditions, but only slightly so at a noise receptor location, where the varying residual sound level may mask the characteristics that may otherwise attract a character correction.

9.9 To establish an appropriate character correction the level and character of sound from the source must be put in the context of the residual soundscape at the noise receptor location. It is not appropriate simply to compare the sound from the source to the background sound level, it must also be compared to other characteristics of the residual soundscape such as how the residual sound level varies with time and the type of sound of which it is comprised.

9.10 The sound level from the ASHP is slightly below the background sound level and significantly below the residual average sound level, so the residual acoustic environment will mask any acoustically distinguishing characteristics. A feature correction is therefore not applicable.

Assessment

9.11 Plant will be operational during the day. Therefore, the reference time interval (T_r) is 1 hour. In reality the unit will not operate at maximum capacity all of the time however the variation in operation will depend upon several factors such as load, and ambient temperature, therefore, it may be prudent to assume a sound level based upon continuous maximum capacity operation throughout this period but be aware that the actual specific sound level will be lower than this.

9.12 Based on the results of the acoustic survey and the calculated cumulative rating level from the proposed fixed plant and equipment the Initial Estimate according to BS 4142, at the potentially most sensitive receptors is shown in Table 8.1 below.

Residual sound level	39 dB $L_{Aeq,1hour}$
Background sound level	35 dB $L_{A90,1hour}$
Specific Level at Receptor	33 dB $L_{Aeq,1hour}$
Character correction	0
Rating level at Receptor	33 dB L_{Ar}
Excess over background sound level	-2 dB
Initial Estimate	An indication of the specified sound source having a low impact, depending on the context

Table 8.1 Initial Estimate of Likely Significance of Impact

Consideration of Context

9.13 The Initial estimate must be reviewed in the context of how the sound will be experienced by the most noise sensitive residents. This review is informed by the authoritative guidance (as summarised in Table 5.1), the nature and residual sound in the area and the changes to that sound that will result from the proposals.

9.14 The context of the area is that of a residential area alongside a moderately busy road. the context of the installation is an environmentally beneficial installation of one air source heat pump to provide heating to one dwelling. There is a national strategic impetus to encourage this type of development provided that it does not create other unacceptable negative impacts such as excessive noise for neighbouring residents. The current national development arrangements, which are currently under review, incorporate a presumption in favour of development which accepts that there will be some negative acoustic impact, particularly for dwellings in quieter locations.

9.15 The aim should therefore be to ensure that sound from the ASHP does not create an unsuitable negative acoustic impact, not to aim to achieve inappropriately low noise levels from the plant.

Overall Assessment

9.16 Table 8.2 below summarises the overall assessment of the sound front the ASHP in the context of the acoustic environment and the recommendations of the current authoritative guidance (as set out in Table 5.1).

Rating level for ASHP	33 dB L_{Ar}
BS 4142 difference between rating level and background sound level	-2 dB
BS 4142 Initial Estimate	An indication of the specified sound source having a low impact, depending on the context
Comparison with existing residual sound	Rating level ~6 dB below existing residual sound levels and ~2 dB below quietest 10% level of sound in the environment
WHO & BS 8233:2014 guidance	ASHP sound below the levels recommended, and will not result in an increase above recommendations when combined with existing residual sound.
NPSE guidance	
Local Authority guidance	Proposed plant complies
Suitable criteria	Proposed plant complies
Overall assessment	Low impact

Table 8.2 Overall Plant Assessment

9.17 The outcome of the assessment, therefore, is an indication of the likely significance of the impact of sound from the plant at nearby noise sensitive receptors. The criteria that have been identified to properly protect noise sensitive receptors take account of the context of the situation, considering the acoustic characteristics of the plant, its hours of operation, the acoustic characteristics of the area where the plant is installed and where the site and noise receptors are situated, together with the locations that may be affected e.g. outdoors in gardens and indoors in habitable rooms during the day.

Uncertainty

9.18 Annex C provides further information regarding the causes and effects of Uncertainty in an acoustic assessment such as this. There is relatively little uncertainty in the measured levels due to the measurement system (perhaps of the order of 1dB or so), but far greater uncertainty in other parts of the assessment.

9.19 The background sound level is representative of a range that can vary by many decibels depending upon factors such as the time of day, season, wind speed and direction. However, the selection of the criteria to ensure that residents are properly protected against disturbance is informed by both the representative background sound levels and authoritative guidance that provides absolute values based on physiological responses to sound and large-scale surveys. These criteria will ensure that residents will not be disturbed by noise from the plant across the range of variation of the background sound level.

9.20 Any acoustic analysis such as those in the Calculation Sheet includes uncertainty due to factors such as the acoustic character of the propagation path from source to receiver. The modelling methods used adopt a conservative approach where appropriate in order to provide some margin of safety to the calculated sound levels.

9.21 There is inevitably further uncertainty in the data provided by plant manufacturers. In some cases, this is relatively small, in other cases much greater. This can be exacerbated by the appropriateness and magnitude of a character correction, which should be based on the subjective characteristics at the noise receptors. However, by applying extensive experience of the types and acoustic characteristics of the selected plant, together with the subjective method of assigning a character correction, it is possible to considerably reduce this level of uncertainty.

9.22 An additional margin of safety is provided by assuming that the ASHP will operate full capacity throughout the reference time period i.e. 1 hour. In reality, it is likely that the ASHP will only operate at maximum capacity for part of the time, as a result of which the actual sound level produced by the plant will be slightly lower than assumed for assessment purposes.

10.0 Conclusions

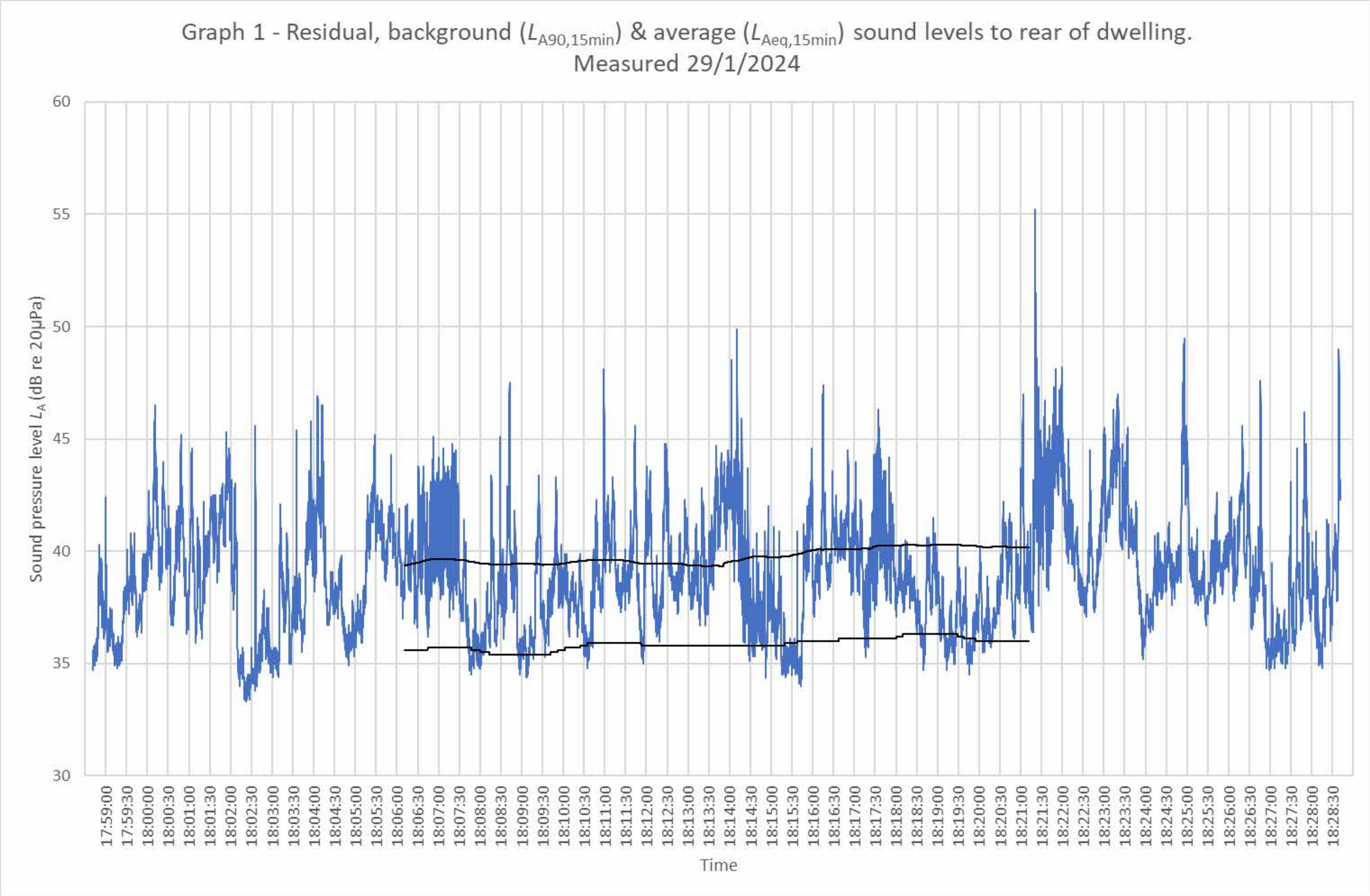
10.1 Acoustical Control Consultants have been appointed to undertake an assessment of the sound from the ASHP at 21 Barton Road, Haslingfield.

10.2 This has been assessed using all appropriate guidance and criteria including relevant Standards, National and Local planning policy and guidance from the Local Authority.

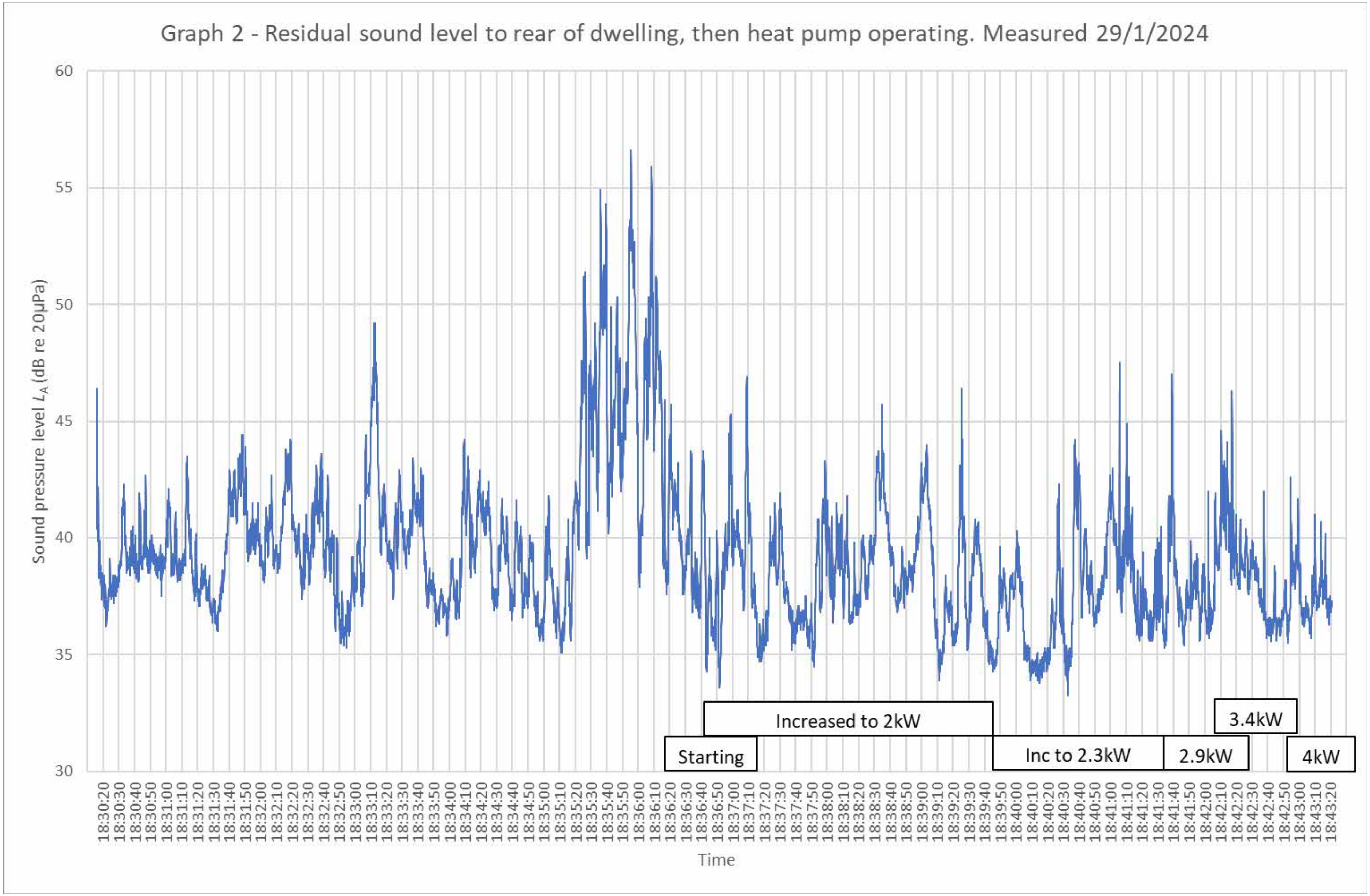
10.3 Sound from the ASHP complies with all criteria and therefore achieves suitable sound levels and the amenity of neighbouring residents is therefore properly protected.

Appendix 1 Measurement Graphs

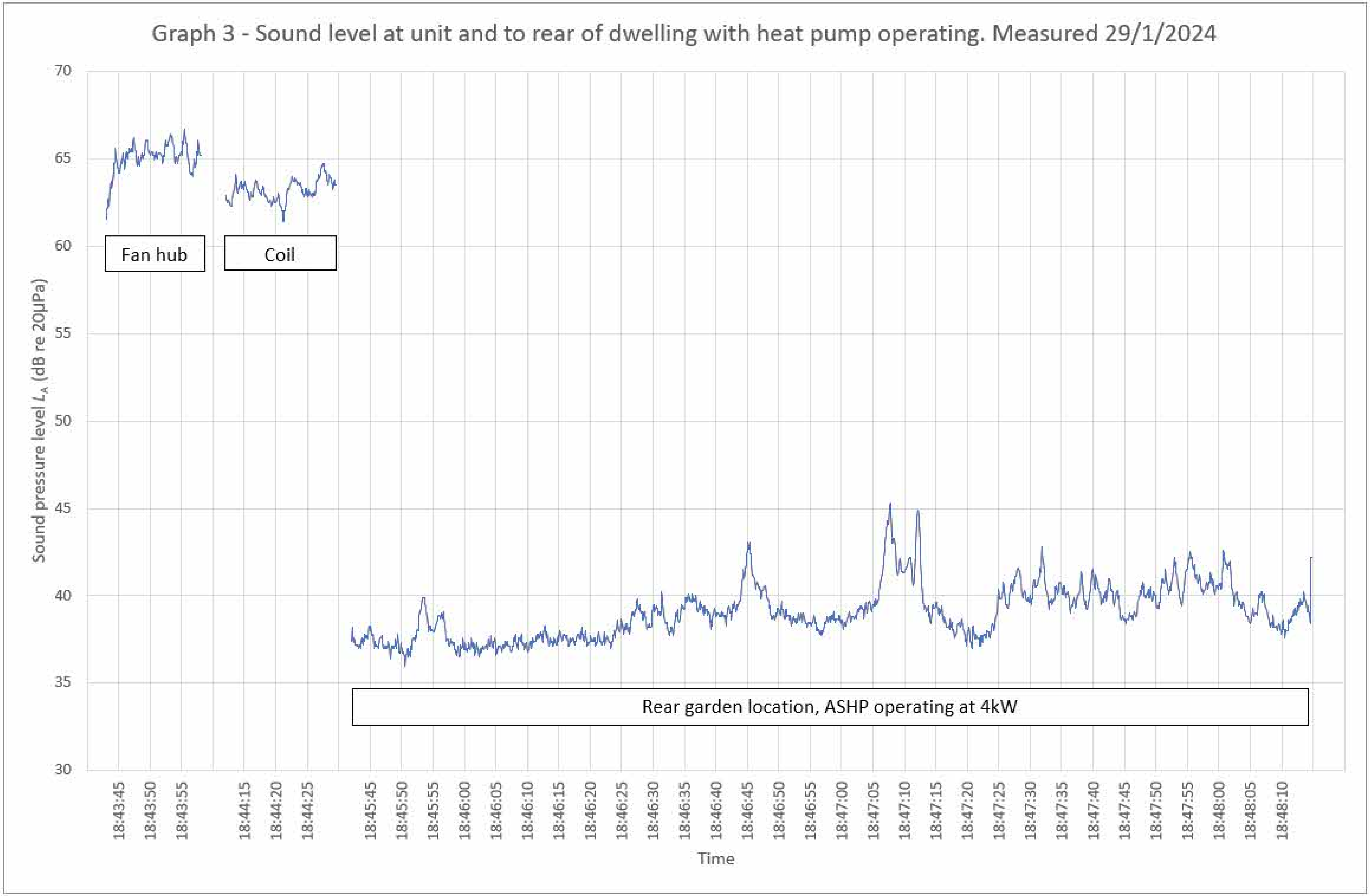
ACOUSTICAL CONTROL Engineers & Consultants



ACOUSTICAL CONTROL Engineers & Consultants



ACOUSTICAL CONTROL Engineers & Consultants



Appendix 2 Calculation Sheets

Calculation Sheet 1 - ASHP Sound Level Analyses

Line	Details		dBA	Notes
1	Underlying residual sound level		34	Conservative (low) level
2	Underlying sound level in garden with ASHP operating at 4kW		36	
3	Calculated Specific (ASHP) Level		32	$10 \text{ Log}_{10} (10^{\text{Line } 2/10} - 10^{\text{Line}1/10})$
4	BS 4142 Feature correction		0	Source masked by residual sound
5	BS 4142 Rating Level at Receptor		32	Lines 3 + 4
6	Background sound level for BS 4142 assessment		35	Range 35 to 36 dB $L_{A90,15min}$ (from Graph 1)
7	Difference between Rating & Background Sound Levels		-3	Lines 5 - 6
8	Manufacturer's stated sound power level		62	
9	Approximate 'effective area' at rear between houses (m^2)	78.5	-19	10 Log_{10} (10m radius, 2.5m gap)
10	Estimated distance & screening attenuation to measurement location		-10	
11	Estimated Specific sound level at measurement location		33	Lines 4 + 5 + 6
12	Sound pressure level at fan hub		65	
13	Effective area (m^2)	0.28	-5	
14	Fan outlet partial sound power level		60	
15	Sound pressure level at coil		63	
16	Correction for adjacent wall		-3	
17	Effective area (m^2)	1.00	0	
18	Coil partial sound power level		60	
19	Calculated ASHP sound power level		63	$10 \text{ Log}_{10} (10^{\text{Line } 10/10} + 10^{\text{Line}14/10})$

Annex A Background sound level

Synopsis

A.1 The background sound level is not a single numerical value but a range that is unlikely to be precisely defined numerically.

A.2 It is equally important to understand the range of factors that affect the background sound level as the actual measured levels.

A.3 Appropriately timed short duration attended measurements can provide much better quality data than unattended measurements taken over a significantly longer period.

Introduction

A.4 The 2014 edition of BS 4142 provides clearer and more specific guidance that the background sound level should be representative and not the lowest level that can be measured. This is to prevent some abuses of the Standard which have occurred in the past, such as where criteria have been set based on the lowest background level measured during any 5 minute period throughout the night.

A.5 Clause 8.1.4 states that: 'The monitoring duration should reflect the range of background sound levels for the period being assessed. In practice, there is no "single" background sound level as this is a fluctuating parameter. However, the background sound level used for the assessment should be representative of the period being assessed'.

A.6 This means that if a single 'representative' background sound level is used for an assessment, consideration must also then be given to the likely range of variation in background sound and its effect on the outcome of the assessment. Ideally, the range of variation should reflect the variation of the residual sound during the period(s) of interest, taking account of both level and likelihood of such levels occurring, rather than simply attempting to consider the maximum potential range between lowest or highest possible sound levels that may occur.

A.7 However, it must also be recognised that the background sound level will usually vary significantly depending upon many different factors such as weather conditions; time of the day or night; day of the week; and time of the year. Even at the same time of day/ night and same time of the year, the background sound level can often vary by more than 10 dBA depending upon wind direction, even under conditions that are all regarded as being 'suitable' for valid measurements to be taken.

A.8 Most residual sound and the associated background sound levels are affected by sources close to the measurement location and also more distant sources such as transportation systems; commercial/ industrial and other human activity; and foliage moving in the wind or even water flowing. The sound level at the measurement location will therefore vary as the wind changes in speed and direction. Sound from more distant sources is affected by wind at low and higher altitudes, which can be significantly different in both speed and direction. Therefore even under apparently similar conditions at the measurement location, the residual sound level may vary to a greater extent than would be expected if the wind at higher altitude is more variable than at lower altitude.

A.9 Whilst it may appear that taking measurements for a few days will provide better data covering a range of weather conditions, this may not be the case. Weather conditions tend to remain fairly similar for several days so a measurement period of this duration is likely to provide several days data for similar conditions. It is also highly unlikely that this period will cover the range of conditions that affect the background sound level which means that the extended measurement period may provide a false sense of reliability of data when it is of no more benefit than that obtained over a single 24 hour period.

A.10 A further problem with this approach is that unattended measurements provide very little or even no data about what has actually been measured. Fully attended measurements enable the acoustic environment to be properly understood and factors that affect the sound level to be identified and their contribution quantified. A short duration attended survey can usually provide far better quality data than a longer term unattended survey, although where long term measuring is required, such as for compliance monitoring, this may not be appropriate.

A.11 Where it is necessary to fully understand the variation in residual sound during the day and night it may be appropriate to take measurements throughout this period. However, this is unlikely to be representative of different conditions such as days of the week, public holidays and even school holiday conditions. In many situations it is more appropriate to specifically consider the most sensitive times of the day or night, on the basis that if these are satisfactory then less sensitive times will also be satisfactory. For plant that operates on a 24/7 basis the most sensitive time of the night is likely to be when people are going to or awakening from sleep rather than the quietest part of the night. During the day the most sensitive time is likely to be the evening when the residual level may be lower than at other times of the day.

Annex B Character correction

Synopsis

B.1 A character correction is applicable if sound has significant characteristics such as tonality or impulsivity that attract a listener's attention at the noise sensitive location to be considered for the assessment.

B.2 A character correction can comprise separate corrections for tonality, impulsivity, other characteristics (if neither tonality nor impulsivity apply), and intermittency. These corrections are additive.

B.3 The subjective method(s) should be used to determine the character correction unless agreement cannot be reached, in which case the objective/ reference methods may be appropriate alternatives.

B.4 Whilst the maximum character correction could arguably be 15 dB or possibly even 18 dB, in reality it is expected that, where a character correction is applicable, a correction in the range of 5 dB to 10 dB is likely to be appropriate in the vast majority of cases.

Introduction

B.5 Sound which has characteristics that attract a listener's attention may be significantly more intrusive than sound of a somewhat higher level that is more innocuous. The most common acoustically distinguishing characteristics are tonality, impulsivity and intermittency. BS 4142provides guidance regarding how a character correction should be determined. It is important to note that this is based on the level and character of the specific sound at the noise sensitive location(s) in comparison to the level, character and context of the residual acoustic environment. It is intended that the subjective method be used where agreement can be reached regarding penalties where appropriate, with the objective/ reference methods only being used in more contentious situations.

B.6 Because the level and character of both the specific and residual sound vary with time, it is likely that the significance of any acoustically distinguishing characteristics will also vary with time. It is most appropriate to establish a character correction for representative conditions but to then consider the range of variation of potential character correction as part of the consideration of the uncertainty of the assessment.

Tonality

B.7 For tonality, Clause 9.2 states that: 'For sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0 dB and +6 dB for tonality. Subjectively, this can be converted to a penalty of 2 dB for a tone which is just perceptible at the noise receptor, 4 dB where it is clearly perceptible, and 6 dB where it is highly perceptible'.

B.8 In most cases where plant produces sound that is tonal but similar in level to the residual sound, the tonality may tend to be slightly or clearly rather than highly perceptible at the noise sensitive location(s), with the relative prominence of the tonality being reduced due to masking by the residual acoustic environment. In such cases it may be appropriate to apply a penalty of 2-4 dB to account for this effect.

Impulsivity

B.9 For impulsivity, Clause 9.2 states that: 'A correction of up to +9 dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3 dB for impulsivity which is just perceptible at the noise receptor, 6 dB where it is clearly perceptible, and 9 dB where it is highly perceptible'.

B.10 In most cases where plant produces sound that is impulsive but similar in level to the residual sound, the impulsivity may tend to be slightly or clearly rather than highly perceptible at the noise sensitive location(s), with the relative prominence of the impulsivity being reduced due to masking by the residual acoustic environment. In such cases it may be appropriate to apply a penalty of 3-6 dB to account for this effect.

Other Characteristics

B.11 Clause 9.2 also states that 'Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied'.

B.12 This means that, depending upon circumstances such as the context, it may be applicable to apply a 3 dB penalty to sound that is neither tonal nor impulsive where it has other characteristics that tend to attract a listener's attention to the sound against the residual acoustic environment at the noise sensitive location(s).

Intermittency

B.13 For intermittency Clause 9.2 states that: 'When the specific sound has identifiable on/off conditions, the specific sound level ought to be representative of the time period of length equal to the reference time interval which contains the greatest total amount of on time. This can necessitate measuring the specific sound over a number of shorter sampling periods that are in combination less than the reference time interval in total, and then calculating the specific sound level for the reference time interval allowing for time when the specific sound is not present. If the intermittency is readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied'.

B.14 This means that, depending upon circumstances such as the context, it may be applicable to apply a 3 dB penalty where the intermittency of the specific sound tends to attract a listener's attention to the sound against the residual acoustic environment at the noise sensitive location(s).

Conclusion

B.15 On an extremely rare occasion when the specific sound is both highly tonal and highly impulsive at a noise sensitive location, it could conceivably be appropriate to apply a character correction of 15 dB and possibly even 18 dB if the intermittency of the specific sound exacerbates the impact of what is already highly intrusive sound still further. If sound is both tonal and impulsive but one of these characteristics is dominant then it may be appropriate to apply just the correction for that characteristic. In situations where the specific sound is similar in level to the residual sound it is more likely that such characteristics will be masked to some extent by the residual sound at the noise sensitive location(s). In this case it is more likely that a character correction of 2-4 dB for tonality and/ or 3-6 dB for impulsivity may be applicable, possibly with an additional 3 dB penalty for intermittency if this is significant. In most cases it is expected that a character correction, if applicable, will be in the range of 5-10 dB.

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Annex C Uncertainty

Synopsis

C.1 Despite sound measurement systems' usual precision of 0.1dB, any measurement of environmental sound or specific components of this can only be representative of its constantly varying level and character, at best.

C.2 In addition to uncertainty in sound level measurement systems, the actual level being measured varies continuously in level and character. Analysis of the measured levels adds further uncertainty, as does assessment of the potential impact of sound, which is greatly affected by the specific context of the situation being assessed.

C.3 It is not appropriate to estimate all uncertainty that may occur and deduct this from a 'suitable' level to establish a 'safe' level that 'should be ok'. This would result in sound levels that are substantially lower than necessary or appropriate, providing no benefit for those being 'protected', whilst creating significant adverse impacts on the sustainability of any development and making many impracticable, thereby preventing much development that should proceed, and denying the benefits of such development, often to the very people that are being 'protected'.

C.4 The way in which uncertainty is addressed must depend upon factors such as the sensitivity of the situation, the potential magnitude of the uncertainty, and its potential significance on the outcome of the assessment.

Introduction

C.5 Environmental sound is constantly changing in level and character. The relative significance of any component of this similarly varies continuously as sound from both the specific component and all other residual sources varies. The propagation paths between sources and receiver change for reasons such as varying wind speed and direction which further alters the level and character of environmental sound at any location. Sound can be measured and expressed in many different ways using different parameters such as the maximum, logarithmic average, minimum, or statistical distribution. These values will themselves depend upon other factors such as the time period over which they apply and the response time of the measurement system. This means that any quantified level of residual sound or that from a specific source is representative rather than precise and it is necessary to more fully understand the acoustic characteristics of the acoustic environment that is being considered.

C.6 Uncertainty has been the acoustic 'elephant in the room' for many years. Some acousticians have considered it; many have ignored it; and other people, particularly non-acousticians, have been unaware of it, assuming incorrectly that acoustic analyses presented to a precision of 1 dB or even 0.1 dB are accurate to that level of accuracy.

C.7 In most cases, when setting sound levels based on an acoustic assessment it is not appropriate to set a criterion that incorporates uncertainty to the extent that the criterion is highly unlikely to be exceeded under any circumstances. Clearly there are some exceptions to this, such as the safety requirement to protect personnel from hearing damage at work. In this case subtracting 1 standard deviation (σ) from a hearing protector's average performance is used to give an assumed level of performance that should be achieved for 84% of users. Although subtracting 2σ would protect 97.5% of users and 3σ would protect 99.9%, a balance has been struck between cost/ practicability and benefit in deciding that uncertainty where 16% of people may not be provided with the expected level of protection is appropriate in this case.

C.8 In non-safety critical situations it is generally appropriate to accept a greater level of uncertainty in the outcome of any assessment. In many acoustic assessments it is also not practicable to numerically quantify the level of uncertainty in the manner that is possible for hearing protection devices which can be thoroughly tested and measured under carefully controlled laboratory conditions.

C.9 BS 4142aims to provide guidance as to the likely significance of impact of industrial or commercial sound, taking into account not only the level and character of that sound but also the context in which it is heard, which can significantly affect the significance of its impact.

C.10 The impact of industrial or commercial sound will vary as the level and character of both the source and residual sound changes. This means that the assessment of its impact will be a general indication and that its significance will change continuously. As noted above, it is generally not appropriate to consider a theoretical 'worst case' scenario comparing the highest possible rating level against the lowest possible background sound level. Instead, representative rating and background sound levels should be compared, considering the level, character and context of the specific sound and residual acoustic environment. There will inevitably be occasions when the impact is slightly greater than this representative situation and conversely there will be other occasions when the impact is less. This is no different to the impact of different sources of sound in the residual acoustic environment, such as pedestrians conversing loudly whilst passing a dwelling, a vehicle horn being sounded, or a siren being heard on occasion.

Measurement Uncertainty

C.11 Any measurement whether acoustic or not, includes an element of uncertainty in the measured value, the magnitude and significance of which usually depends upon many factors. The most obvious factor for measurements undertaken for this assessment is due to instrumentation, but this is minimised by a range of controls set out in Craven & Kerry's 'A Good Practice Guide on the Sources and Magnitude of Uncertainty Arising in the Practical Measurement of Environmental Noise' (as referenced in BS 4142: 2014) including:

- Use of Type 1 sound level analysers
- Bi-annual calibration of sound level analysers and annual calibration of calibrators (relevant calibration certificates are provided elsewhere.
- Periodic cross-calibration with other calibrated analysers and monitoring of system's calibration characteristics.
- On site calibration checks before and after measurements are taken.
- Avoidance and control of interference due to electromagnetic sources, weather or other factors.

Other Causes of Uncertainty

C.12 These measures ensure that the uncertainty due to the measurement system is relatively small in comparison with factors that affect the overall uncertainty incorporated in this assessment. These include:

- Variations in the level and character of residual and associated background sound at the measurement and noise sensitive receptor locations.
- Variations in the level and character of the specific sound.
- Where the specific sound level is calculated from the difference between the ambient sound level with the source operating and the residual level without, significant variability in either of these levels increases the uncertainty in the calculated specific level and significant variability in both increases the uncertainty by a greater amount.
- The magnitude of any character correction that should be applied and under which conditions e.g. full load or partial load operation or different plant characteristics.
- Modelling of the sound path from source to receptor.

C.13 In addition to the Good Practice measures identified by Craven and Kerry, appropriate measurement techniques can further reduce uncertainty such as undertaking fully attended surveys, recording the sound level many times each second and noting acoustically significant factors that may affect the measured level on a second by second basis.

Background & Residual Sound Level Uncertainty

C.14 In many cases the level and character of residual and background sound is strongly affected not only by the level of activity which varies with time of day, but also by seasonal effects such as foliage generated noise and to an even greater extent by weather conditions, of which the most significant is usually wind speed and direction, which itself varies with location and altitude. Because weather conditions tend to remain fairly similar for several days, taking measurements for this length of time is likely to provide a few days and nights of similar data rather than a reflection of the likely range of sound levels under different weather conditions. Where it is necessary to fully understand this effect it is necessary to undertake long term monitoring for extended periods, generally also at different times of the year. Clearly this is only likely to be practicable for major developments such as national infrastructure construction. Even for large windfarms it is usually only considered appropriate to gather data for a period of many weeks rather than many months. Long term residual and background sound level measurements are neither practicable nor appropriate for small scale developments, particularly if the background sound level informs rather than dictates the outcome of a BS 4142assessment.

C.15 Where the residual sound level is relatively steady measuring for a short time can provide as good an indication of the representative level prevailing at that time under those specific as a longer duration measurement. As the variability of the residual sound level increases the range of residual and background sound levels also increases and the uncertainty in these levels similarly increases. However, as discussed above, the variability and uncertainty in the residual and background sound levels will tend to be greater under different weather conditions than at different times of the day or night under similar weather conditions. Measuring the sound level many times every second provides a clear understanding of how the sound level depends upon a range of factors such as passing traffic, distant plant and activity, so that the likely range of variation of the residual and background sound levels can be better understood.

C.16 There is a balance to be struck between reducing uncertainty and the duration and associated costs of the measurement period(s).

Source Level Uncertainty

C.17 There is uncertainty in the level and character of sound from sources for many reasons. These include:

Varying plant operational conditions.
Variation in sound level produced by different items of equipment.
Uncertainty or error in manufacturer's data.
Uncertainty or error in measured levels of other 'representative' sources.
Acoustic characteristics of plant such as directivity.

C.18 Plant may operate differently under different conditions and for example, may be restricted so that the level and character of sound will be different during the night than day time. Even where plant operates in only one mode, the level and character of sound that it produces may vary. BS 4142considers the average sound level that the plant may produce over a 15 minute period during the night and 1 hour during the day. The characteristics of the sound may also differ during these times as a result of which the rating correction(s) may be different.

C.19 Where there are multiple items of equipment, the variation in level and character of each is likely to result in even greater variation of the overall level and character of sound from the equipment as a whole. However, there can also be some 'smoothing' effect if the overall result is that plant operates more or less continuously, with individual items of plant starting and stopping at different times. Provided that the changes in level and character due to individual items of plant are not significant this can result in slight variations in an otherwise relatively steady sound that may be less significant than a single item of plant intermittently stopping and starting.

C.20 Where a new source is proposed, it may be appropriate/ necessary to use manufacturer's data to assess the likely significance of its impact. This data may vary from a single figure dBA level that may or may not clarify whether it is a sound pressure level measured at a specific distance under known acoustic conditions, or a sound power level, to a detailed frequency spectrum, possibly for different operating conditions. Experience can greatly assist the interpretation of such data and the assessment of its reliability. Even where detailed frequency spectra are provided, this does not provide a definitive indication of appropriateness or otherwise of a character correction and its magnitude if this is found to be applicable.

C.21 In many cases it is appropriate to use data obtained from other similar equipment as an indication of the likely level and character of sound that will be produced by proposed plant. In these cases it is necessary to consider the uncertainty in these measured levels including not only the effects of the measurement environment and operational characteristics of the representative plant, but also any differences due to other factors such as required maintenance.

Character correction Uncertainty

C.22 The character correction includes corrections for sound that is tonal, impulsive, intermittent, or has other characteristics that will tend to attract a listener's attention. The significance of these characteristics should be assessed by comparison of the specific and residual sound at the noise sensitive location(s), not closer to the source. This may be difficult to do for existing sources due to difficulties in measuring the specific and residual sound, although in most cases it should be possible to use the simplified subjective method set out in clause 9.2 of BS 4142.

C.23 For a proposed source it will not be possible to directly measure or subjectively assess the sound it produces at the noise sensitive receptors, but it may still be possible to apply the subjective method in such situations, considering the known level and character of sound the source will produce and the level and character of the residual acoustic environment at the noise sensitive location(s).

C.24 There may be uncertainty whether a specific sound may have tonal or impulsive content that is just or clearly perceptible; or is clearly or highly perceptible. It is up to the parties undertaking the assessment to form an opinion regarding what would constitute an appropriate character correction and to clearly explain how this has been arrived at. The uncertainty in the magnitude of the character correction and the likely significance of the character of the specific sound at the noise sensitive location(s) should then be considered further as part of the assessment process.

Modelling Uncertainty

C.25 Where an existing source is being assessed based on measurements and observations at the noise sensitive location(s) there may be no need for any acoustic modelling of the source characteristics or sound propagation path. However, in most cases it is likely that a combination of measurement and calculation will be necessary and this will introduce further uncertainty. For example levels measured close to a source can be extrapolated back to the noise sensitive location(s) but the actual level produced at the more distant location(s) will be affected by factors such as reflections or screening by structures, attenuation due to the ground or air, and possibly most significantly by wind speed and direction.

Conclusion

C.26 Some of the elements of uncertainty that affect the actual level and character of sound at noise sensitive locations can be numerically estimated, although this is unlikely to be the case for the more significant ones. However, the aim is not to derive a precise numerical outcome from a BS 4142assessment but to consider the likely significance of the impact of industrial or commercial sound at affected noise sensitive locations.

C.27 Where there is a very clear outcome and relatively small uncertainty, then the uncertainty will have negligible effect on the outcome of the assessment. However, where the outcome is less clear and/ or the level of uncertainty is greater, this should be reflected in the assessment.

C.28 The assessment must consider not only the level and character of sound from the source(s) and also the residual acoustic environment but also the context in which it is experienced. The effect of sound on a listener is subjective and it is necessary to incorporate some subjectivity into a BS 4142 assessment. This is generally the most appropriate way in which to incorporate the effects of uncertainty into the outcome of the assessment.

Annex D Guidance

Synopsis

D.1 BS 4142:2014 uses a comparison between the rating and background sound levels to establish an Initial Estimate of the Likely Significance of Impact. The context of the assessment must then be considered, which can significantly alter the outcome of the assessment.

D.2 Where the aim is to ensure that people are not disturbed by plant during the night it is the absolute level of sound within the dwelling that will be of most significance. What constitute a suitable level of sound from plant will depend upon the character of the acoustic environment. This means that identification of a suitable criterion to properly protect residents must be informed by the existing residual sound level, of which the background sound level is one partial indicator, with others such as the average or maximum providing further information.

D.3 For gardens and other outdoor amenity areas, BS 8233indicates that an average level of 50dBA may be desirable, but this is based on considering residential development in what may be relatively noisy areas. For quieter locations other guidance provide further assistance. When establishing what may be a suitable level in gardens etc. for sound from plant, it is important to consider the existing acoustic environment including the residual levels (background, average, etc.) and the character of the area e.g. quiet rural, busy urban, adjacent to a car park or service yard.

BS 4142:2014+A1:2019 Methods of rating industrial and commercial sound

D.4 BS 4142:2014 differs from previous editions of this Standard in many ways, including that:

The aim is to assess the likely significance of impact not the likelihood of complaint. This is consistent with current Government planning policy but is not aligned to it because this is a British standard, whereas planning policy does not apply to all of Britain.

The context of the situation must be considered as part of and can significantly affect the outcome of the assessment.

The outcome of the numerical assessment will not be a single number but a range, together with uncertainty, the significance of which must be considered as part of the assessment process.

The absolute sound levels may be more significant than the difference between the rating and background sound levels.

It may also be appropriate to consider other guidance such as BS 8233:2014 as part of the assessment.

Sound having significant characteristics that attract a listener's attention may be significantly more intrusive than featureless sound of a somewhat higher level, as a result of which the character correction may now be significantly greater than before.

The reference to a rating level 10 dB below the background sound level has been removed because this was mis-applied in many cases to impose unreasonably low criteria.

The many factors that affect the uncertainty of an assessment must be taken into account.

D.5 Clause 11 states: 'The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context'.

D.6 BS 4142requires that the rating level be compared to the background sound level to provide an Initial Estimate of the Likely Significance of Impact. This is then amended to take account of the context of the assessment, and the effects of the uncertainty in the entire process on the outcome of the assessment must also be considered.

D.7 The background sound level ($L_{A90,T}$) is defined as the level exceeded for 90% of the time i.e. the quietest 10% level. This specifically excludes consideration of the sound level prevailing for 90% of the time and is intended to provide an indication of the sound level during 'lulls' in activity. This means that the same background sound level can be measured outside a dwelling in a continuously quiet location with little activity or sources of residual sound, and outside a dwelling beside a road with vehicles passing at high speed every few minutes. Clearly these two locations have very different acoustic characteristics and sensitivity to sound, despite having the same L_{A90} level. In this situation the average ($L_{Aeq,T}$) levels may differ by around 20dBA to 30dBA and the maximum ($L_{AMax,T}$) levels may differ by 40dBA or more.

BS 8233:2014 Guidance on sound insulation and noise reduction for buildings

D.8 This Standard draws on authoritative guidance such as that issued by the World Health Organisation to identify suitable noise levels for a wide range of different environments. For dwellings these include bedrooms, where the aim is to protect people from sleep disturbance; other habitable rooms that are in use during the day, where the aim is to provide good listening/ communication/ recreational conditions; and outdoor amenity space including gardens.

D.9 This confirms that a steady average level of 30dBA within a bedroom, due to external sound sources, is desirable and that this should not have significant acoustically distinguishing characteristics. For habitable rooms during the day a desirable level is 35dBA.

D.10 For outdoor areas such as gardens and patios a desirable upper average level of 50dBA is stated, with an upper guideline average limit of 55dBA, which would be acceptable in noisier environments. However it is also recognised that for strategic reasons it may be appropriate to permit higher levels, such as for new dwellings in busy urban areas.

National Planning Policy Framework (NPPF), Noise Policy Statement for England (NPSE) and National Planning Practice Guidance (NPPG)

D.11 These documents clarify Government policy regarding development and noise. There is a presumption in favour of sustainable development and a recognition that when considering sustainability, the various factors that affect the sustainability of a proposed development must be considered collectively.

D.12 The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities.

D.13 Paragraph 123 of NPPF states that:

> Planning policies and decisions should aim to:
>
> a. avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
>
> b. mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;
>
> c. recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and
>
> d. identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

D.14 The Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy by promoting good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

D.15 Paragraph 2.23 of NPSE clarifies the first part of the above excerpt:

a. The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development.

D.16 Similarly paragraph 2.24 of NPSE clarifies the second part:

a. The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL (Lowest Observed Adverse Effect Level) and SOAEL (Significant Observed Adverse Effect Level). It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur.

D.17 These make it clear that noise must not be considered in isolation but as part of the overall sustainability and associated impacts of the proposed development. There is no benefit in reducing noise to an excessively low level, particularly if this creates or increases some other adverse impact. Similarly, it may be appropriate for noise to have an adverse impact if this is outweighed by the reduction or removal of some other adverse impact that is of greater significance when considering the overall sustainability of the proposed development.

D.18 NPSE clarifies the difference between NOEL (No Observed Effect Level) and LOAEL as used in Night Noise Guidelines for Europe, which gives values of 30dB(A) and 40dB(A) for the night time average level measured outside dwellings respectively. This indicates that there may be no significant overall benefit in achieving an average level of less than around 40dB(A) outside dwellings during the night.

D.19 It should also be considered that in order to make equipment quieter it is often necessary to use larger equipment that operates more slowly and for longer periods of time. This may increase energy consumption and hence the carbon footprint of the equipment. The overall impact of this may outweigh any acoustic benefit of the equipment being slightly quieter.

World Health Organisation: Guidelines for Community Noise; Night Noise Guidelines for Europe

D.20 The WHO publication 'Guidelines for Community Noise – 1999' provides guidance regarding suitable levels of noise that will protect vulnerable groups against sleep disturbance. A steady level of 30dB(A) in bedrooms, with occasional maximum levels of 45dB(A) are identified as being suitable to achieve this, with an assumed difference of approximately 15dB(A) between the noise level outdoors and that resulting in the bedroom, assuming that the bedroom windows are partly open for ventilation. This means that the corresponding targets for the noise level outdoors are steady levels of up to about 45dB(A) and occasional maxima of up to around 60dB(A).

D.21 The more recent WHO guidance 'Night Noise Guidelines for Europe – 2009' is more concerned with the longer term average noise levels that are covered by the EU Directive on Environmental Noise, although this does appear to suggest slightly lower external maximum noise levels of around 57dB(A) outside bedrooms during the night.

D.22 Furthermore the 1999 guidance states that: 'To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55dBLAeq on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50dBLAeq. Where it is practicable and feasible, the lower outdoor level should be considered the maximum desirable sound level for new development.'

Annex E Assessment of the Impacts

Assessment Method

E.1 Clause 11 states: 'The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context'.

E.2 An initial estimate of the impact should be made by subtracting the background sound level from the rating level, and it may be appropriate to make more than one assessment.

E.3 This initial estimate must then be modified as appropriate to take account of the context. This must consider all pertinent factors including:

The absolute level of sound. This may be more as or more significant than the difference between the rating and background sound levels, particularly where the residual sound level is particularly high or low.

The character and level of the residual sound compared to the character and level of the specific sound.

The sensitivity of the receptor and whether the receptor may be protected by specific measures that will reduce the impact in comparison to receptors without such protection.

Specific Considerations

E.4 Clause 8.1 includes the following: 'the middle of the night can be distinctly different (and potentially of lesser importance) compared to the start or end of the night-time period for sleep purposes'.

E.5 Annex A of the Standard provides an increased number of examples of how to use the standard to obtain ratings for various different scenarios. This states that: 'These examples illustrate how the standard could be applied and are not to be taken as a definitive interpretation of how it is intended to be used'.

E.6 Examples 6, 7 & 8 of Annex A 'show how similar sound levels can produce different results, depending primarily upon the context in which the sound occurs'. Examples 6 & 8 specifically consider the likely significance of the specific sound during the night on residents 'who could be sleeping with open bedroom windows'. In this case other guidance such as BS 8233 might also be applicable for several reasons:

At low external residual sound levels the sound level within a dwelling with open windows is likely to be controlled not by the external residual sound level but by sounds created within the dwelling by a range of sources including refrigerators, pumps, boilers, water flowing through pipes, conversation, radios/ televisions, equipment cooling fans, animals, and even people breathing particularly when considering sound during the night.

During the night people the level and character of sound outside a dwelling is of less significance than the acoustic environment within bedrooms and its suitability for going to sleep or not disturbing residents whilst asleep.

The World Health Organisation provides authoritative guidance regarding suitable sound levels in bedrooms, from which the guidance in BS 8233is derived.

Annex F Competence & Experience

F.1 Acoustical Control Consultants Limited has the advantage of personnel that were directly involved in the drafting of BS 4142, who have specialised in the measurement, assessment and control of noise from industrial and commercial sources throughout their careers. This type of work forms a major part of our activity and has done so for several decades. Our culture, systems and working practices are geared towards ensuring that this type of work is consistently undertaken to the high and robust level of quality for which we are known.

F.2 Richard A Collman has overall responsibility for ACC's activities including BS 4142 assessments. He graduated with a BSc (Class I) in Acoustics and Computer Science from Salford University in 1984, being awarded the course prize in both the second and final years. He is a Chartered Engineer and has specialised in the measurement and assessment of sound from industrial and commercial plant for over 30 years, writing articles and papers on this subject for Acoustics Bulletin and IOA conferences. He pioneered the use of digital instrumentation for short duration consecutive logging rather than longer term statistical averaging measurement techniques. As an expert on sound from refrigeration and air conditioning plant he represented the Institute of Refrigeration on the BSI committee and the Drafting Panel responsible for the 2014 edition of BS 4142, presented the section on Uncertainty at the BS 4142Launch Meeting in November 2014, and authored an associated Technical Article in Acoustics Bulletin. He has been closely involved in the development of BRL's BS 4142 measurement, assessment and reporting system to ensure that it is fully compliant with all aspects of BS 4142.

F.3 Mike Hewett, Principal Acoustician, joined the company in February 2021 bringing with him more than 30 years' experience of Acoustic consultancy. Mike's particular expertise is in the assessment, prediction and control of noise and vibration from structures, plant and equipment. Other skills include acoustic design, environmental acoustics and the assessment and control of vibration. He has managed several large-scale acoustic design projects and is highly experienced in diagnostic techniques including sound mapping, sound intensity and vibration measurements. He is an active member of the Institute of Acoustics has been chair and secretary of the Noise and Vibration Engineering specialist group and chair of the North West regional branch. In 1994 Mike was awarded the prize for the best overall performance in the IOA Diploma and has since presented papers at numerous conferences and seminars.

F.4 Kristoffer Tsinontas, Acoustician joined the company in September 2014 and has since been carrying out noise impact assessments primarily for the food retail industry, along with assisting in other larger projects undertaken by the company. Kristoffer has a BSc (Hons) in Music Technology, whereby he specialised in Acoustics and Psychoacoustics – particularly in modelling acoustic soundscapes. Kristoffer is a member of the Institute of Acoustics.

Annex G Acoustics Terms and Glossary

This Annex provides a layperson's explanation of the acoustics terms that commonly appear in reports. It is not intended to give full scientific definitions and explanations or go into detail on how and why things are as they are. Some obsolete terms and abbreviations have been included as they still appear in documents from time to time.

Jargon Buster

Many words have more specific meanings when used in acoustics than in every-day language.	
sound	is used to describe the physical phenomenon of the transmission of energy through gaseous or liquid media via rapid fluctuations in pressure.
vibration	is used to describe the transmission of energy through solid media by oscillation
structure borne sound	The sound radiated from a structure as a result of vibration passing through it from a source in another location
level	used solely to describe values measured in decibels
loudness	is the human perception of the level of sound
noise	can have several definitions and is often used interchangeably with sound however it is usually taken to mean 'unwanted' sound
index	a value based on the mathematical processing of raw data
indicator	a value used to indicate the likelihood of a particular response of effect eg. $L_{10,18hr}$ is an index based on statistical processing of sound pressure data that is used as an indicator for road traffic noise response.
weighted	values modified to reflect sensitivities at particular frequencies.
apparent	measured in situ
standardised	a generalised value based on an in-situ measurement with a correction based on a space with a standard reverberation time value
normalised	a generalised value based on an in-situ measurement with a correction based on space with a standard absorption area
insulation	resistance to the passage of airborne sound
isolation	resistance to the passage of vibration
insertion loss	actual reduction in sound achieved by a structure or system in situ
dynamic insertion loss	in a ducted system the actual reduction in sound power achieved by an attenuator in real flow conditions
static insertion loss	in a ducted system the reduction in sound power achieved by an attenuator in the absence of fluid flow
attenuation	amount by which sound or vibration is reduced when passing through a structure or system
directivity	the amount by which a source radiates more sound in one direction than another.

decibels dB	The decibel is not a true measurement unit nor is it exclusive to acoustics. The decibel is a logarithmic ratio of two values of a variable. Decibels are used because they can represent very wide ranges of ratios (from trillionths and billionths to billions and trillions) with a small range of decibel values. Decibels can be used to represent measured values by using a known reference value in the ratio. When using decibels to measure something it is therefore important to specify what variable is actually being measured and what reference level has been used. This is done by adding a reference value statement in the form "dB re x units", where the units indicate the variable being measured and x is the reference value. Decibels are used in acoustics because the human ear responds to sound in a logarithmic way and the quantities measured in acoustics vary over wide ranges. However, decibels are used in acoustics to measure several different things, which it is important not to confuse with each other. To avoid confusion there is a notation system that identifies what a decibel value is for. The notations take the form of an italic capital letter and some subscript characters. The capital identifies the general type of value and the subscripts give specific details of what is being represented. L_{xxx} denotes a level (ie a value measured in dB by comparison with a reference value); D_{xxx} denotes a difference between two levels; R_{xxx} denotes a rating (or index), which is measure of the generalised acoustic performance of a material or construction based on a difference between two levels; C_{xxx} denotes a correction (or constant) Of these only those with L notations require a reference value statement. Those with D or R notations are effectively ratios of two measured values not one measured value and a reference value and those with C notations are not based on reference values at all. A reference value statement therefore has no meaning when describing D, R and C decibels. Because decibels are logarithmic they have to be added, subtracted, multiplied, divided and averaged using different techniques from normal numbers.
Sound Pressure Level L_p obsolete – SPL	This is the basic measure of how much sound there is at a given location. It is a measure of the size of the pressure fluctuations in the air that we perceive as sound. Sound Pressure Level is expressed in decibels with a reference level of 20 µPa (L_p in dB re 20 µPa)

Sound Power Level L_W obsolete – SWL	This is the total amount of sound produced by a source. It cannot be measured directly but it can be calculated from Sound Pressure Level measurements in known conditions. It can be used to predict the Sound Pressure Level at any point. Sound Power Level is expressed in decibels with a reference level of 1 pW (L_W in dB re 1 pW). In the US a reference of 100 fW is sometimes used
Pitch, frequency tonal sound broadband sound impulsive sound frequency analysis	The sound we perceive can have different characteristics such as low-pitched hums, high-pitched squeals and impulsive sounds. In engineering acoustics the word frequency rather than pitch tends to be used when describing the characteristics of a sound. The unit of frequency is the Hertz (Hz), which is the number of pressure fluctuations per second. Any sound can be defined by its frequency content. Some sounds comprise just one discrete frequency (tonal sounds). Others are distributed over wide frequency ranges (broad band sound). Impulsive sounds are made up short pulses of high frequency components. Sources often produce all of these types of sound at the same time. There are different ways of analysing and displaying the frequency content of a sound: Octave Band Analysis – is the simplest method. The audible range of frequencies is divided into 10 bands. Third-Octave Band Analysis – more detailed with 30 bands Narrow Band Analysis – 12th Octave (120 bands), 24th Octave (240), Fast Fourier (FFT) Analysis – a high resolution technique that can give extremely detailed information on frequency content

A-weighting L_A or L_{pA}, L_{WA}, obsolete – dBA, dB(A) similar – C-weighting L_C or L_{pC}, L_{WC}	The human ear does not sense all frequencies of sound equally. Our sensitivity is at a maximum at around 2 kHz and steadily decreases above and below. Below 20 Hz and above about 20 kHz we can't hear at all. As we get older our higher frequency hearing deteriorates and the upper end of the range comes down from 20 kHz Within its operating limits a precision measurement microphone measures all frequencies the same so the output it produces does not reflect what we would actually hear. The A-weighting is an electronic filter that matches the response of a sound level meter to that of the average human ear at typical ambient sound levels. When A-weighted the Sound Pressure Level L_p becomes L_{pA} (or L_A) and the Sound Power Level L_W becomes L_{WA}. It used to be common to identify that a level was A-weighted by writing dB(A) or dBA instead of dB. Technically these terms are now obsolete as they conflict with other, non-acoustic, uses of decibels but they are widely understood in industry and are therefore still commonly used. The response of the human ear varies depending on how loud the sound is. A-weighting matches the response of a sound level meter to human hearing at around 40 dB. For higher levels there are other weightings the most commonly seen of which is the C-weighting.
Noise Rating NR similar – NC	Sounds of different frequencies behave differently when they reflect from surfaces, pass through partitions or deflect over barriers. These varying properties have to be considered when making acoustic design decisions. It is therefore sometimes appropriate, when specifying noise levels, to define limits in octave bands rather than just an overall A-weighted level. Sometimes specifications for individual octave bands are derived specifically for a given situation. In other situations it is appropriate to use a standard set of octave band limits such as the Noise Rating Curves. The Noise Rating (NR) for a measured sound spectrum is obtained by plotting the un-weighted octave band levels on a set of NR curves. The NR value is the highest curve that is crossed by any one octave band. Noise Criterion (NC) curves are based on a similar principle but the curves are a slightly different shape. At low frequencies NC curves are lower in level than the equivalent NR curves.

Sound can vary significantly with time and these variations can be represented in different ways, such as:

L_p L_{pA} (or L_A) L_{AF}, L_{AS}	The instantaneous sound pressure level (L_p) The A-weighted instantaneous sound pressure level (L_{pA} or L_A) This is the level calculated from the root mean square size of the pressure fluctuations in the air at any given moment. This level can fluctuate greatly even for seemingly steady sounds. To make sound level meters easier to read the values on the display are smoothed or damped out. This is effectively done by taking an exponential rolling average of the previous 0.125 s (FAST time constant) or the previous 1 s (SLOW time constant). The letters F or S are added to the subscripts in the notation to indicate when the FAST or SLOW time constant has been used. These are often omitted but it is good practice to include them. The instantaneous sound pressure level can be sampled at regular intervals to give a profile in graphical or tabular format. This data can then be used to derive other indices and indicators based on targeted periods within a measurement.
L_{max} L_{Amax} L_{AFmax} L_{min} , L_{Fmin}	The maximum instantaneous sound pressure level (L_{max}), The A-weighted maximum instantaneous sound pressure level (L_{Amax}) The A-weighted maximum instantaneous sound pressure level with a FAST time constant (L_{AFmax}). This is the highest instantaneous sound pressure level reached during a measurement period. The opposite of the L_{max} is the minimum instantaneous sound pressure level or L_{min} etc. It is good practice to include the letter which identifies the time constant used as this can make a significant difference to the value.
L_{peak} L_{Apeak} , L_{Cpeak}	The peak sound pressure level (L_{peak}) The A (or C)-weighted peak sound pressure level (L_{Apeak} or L_{Cpeak}) This is the size of the single largest pressure fluctuation during a measurement. It is different from the L_{Amax} as it is not based on the RMS value. This value is sometimes quoted as a peak acoustic pressure in Pascals rather than a peak sound pressure level in dB re 20 [redacted]a.
$L_{eq,T}$ $L_{Aeq,T}$ $_T$ = measurement time eg. $L_{Aeq,5min}$	The equivalent continuous sound pressure level over period T ($L_{eq,T}$), The A-weighted equivalent continuous sound pressure level over period T ($L_{Aeq,T}$). This is effectively the average sound pressure level over a given period. However, as the decibel is a logarithmic quantity, the L_{eq} is not a simple arithmetic mean value. The L_{eq} is calculated from the raw sound pressure data. Therefore, it is not appropriate to include a reference to the FAST and SLOW time constants in the notation

$L_{N,T}$ $L_{AN,T}$ $L_{AFN,T}$ $_N$ = %age value, 0-100 $_T$ = measurement time eg. L_{A90}, L_{A10}, $L_{AF90, 5 min}$	The percentage exceedence sound pressure level ($L_{N,T}$), The A-weighted percentage exceedence sound pressure level ($L_{AN,T}$), the A-weighted percentage exceedence sound pressure level with a FAST time constant ($L_{AFN,T}$). This is the sound pressure level exceeded for N% of time period T. eg. If an A-weighted level of x dB is exceeded for a total of 6 minutes within one hour, the level will have been above x dB for 10% of the measurement period. This is written as $L_{A10,1hr}$ = x dB. L_{A0} (the level exceeded for 0 % of the time) is equivalent to the L_{Amax} and L_{A100} (the level exceeded for 100 % of the time) is equivalent to the L_{Amin}. There is no standard method of calculating the $L_{N,T}$ it can be based on sampled instantaneous sound pressure level profiles or short duration L_{eq} values. If the calculation is based on instantaneous sound pressure values, then the time constant used can make a significant difference to the results and should be stated.
L_E, L_{AE} obsolete – SEL, L_X	The sound exposure level (L_E), A-weighted sound exposure level (L_{AE}). This is a means of comparing the sound energy in discrete noise events like train passes or aircraft flyovers. It is the notional level of a sound lasting 1 second that would contain the same sound energy the whole event being measured. As a result, a short loud event can have the same L_E as a longer duration lower level event. The L_E is identical to the single event equivalent sound pressure level L_X
$L_{EX, 8hr}$ obsolete – $L_{Ep,d}$	Daily noise exposure level The value is a measure of personal noise exposure. This is a product of the noise levels to which the individual is exposed and the time for which that exposure takes place averaged out over the length of a standard working day. Short duration exposures to high noise levels can produce similar personal noise exposure levels to longer exposures at lower levels. In the simplest case if a worker is exposed to a constant noise level for an 8-hour working day their personal noise exposure level will have the same value as the noise level to which they are exposed.

Types of decibels used in specific situations

L_n (NB. different from L_N see above)	The normalised impact sound pressure level The value is a measure of the performance of a floor system and its ability to attenuate foot fall or impact noise under laboratory conditions. The L_n is the level of noise produced by a standard tapping machine measured in the room below the floor being tested. The lower the L_n the better the impact isolation achieved. L_n values are measured and quoted in third-octaves between 100 Hz and 3.15 kHz
L'_{nT}	The standardized impact sound pressure level The value is a measure of the performance of an in situ floor system and its ability to attenuate foot fall or impact noise. The value takes into account the quantity of acoustic absorption within the receiving room. The lower the L'_{nT} the better the impact isolation achieved. L_n values are quoted in third-octaves between 100 Hz and 3.15 kHz
$L'_{nT,w}$	The normalised weighted impact sound pressure level A single value of the $L_{n'T}$ derived from the third octave values using the method described in BS EN ISO 717-2.
D	The level difference The difference between two measured sound pressure levels. In building acoustics this is usually the difference between the levels in tow adjacent rooms measured to determine the sound insulation performance of the partition between them. In this context D values are usually quoted in third-octave bands between 100 and 3.15 kHz.
D_w	The weighted level difference. A simple measure of the sound insulation performance of a partition. A single value of the level difference between two rooms based on third-octave values weighted in accordance with the procedures set down in BS EN ISO 717-1.
R	The sound reduction index This a measure of the sound insulation performance a material or construction measured under laboratory conditions in accordance with BS EN ISO 140-3. R differs from D in that it takes account of the area of the construction under test as well as the absorption in the receiving room, both of these factors influence the measured D. Taking into account these factors allows the R for different constructions to be compared on a like for like basis. R values are quoted in third-octaves between 100 Hz and 3.15 kHz
R_w	The weighted sound reduction index A single value of the R derived from the third octave values of R using the method described in BS EN ISO 717-1. Partitioning and building board manufacturers commonly use this index to describe the inherent sound insulation performance of their products.
R′	The apparent sound reduction index This the equivalent of R measured in situ rather than in full laboratory conditions. These measurements are made in accordance with BS EN ISO 140-4.
R'_w	The weighted apparent sound reduction A single value of the R′ derived from the third octave values of R′ using the method described in BS EN ISO 717-1.

D_{nT}	The standardised level difference There are occasions when neither D nor R′ are the most appropriate descriptors for in situ measurements. An alternative is the D_{nT}, which is D corrected to allow for the reverberation time within the receiving room. Measurements are made in accordance with BS EN ISO 140-4.
D_{nTw}	The weighted standardised level difference A single value of the D_{nT} derived from the third octave values using the method described in BS EN ISO 717-1.
D_{ne}	The normalised level difference of a building element This is a measure of the acoustic performance of a discrete building element or such as a trickle ventilator. The level difference is established within a laboratory and normalised to a reference area of absorption which is $10m^2$.
C_{tr}	This is a correction factor applied to the D_{nTw} to take account of a specific sound spectrum, in accordance with BS EN ISO 717-1. The C_{tr} spectrum is used to characterise many types of prevailing indoor and outdoor noise sources and has been introduced to improve the low frequency performance of wall constructions.

Non decibel quantities used in acoustics.

Reverberation Time T T_{60}, T_{30}, T_{20} RT	The length of time in seconds it takes for the sound pressure level to decay by 60 dB in an enclosed space after the source has stopped. It is not always possible to measure a full 60 dB sound decay, so reverberation time is often measured by multiplying the times taken to decay by 20 dB or 30 dB to give the equivalent of 60 dB decay time (these are often called T_{20} and T_{30} values). The longer the reverberation time the more reverberant the space. Different types of spaces have different ideal reverberation times.
T_{mf}	The reverberation time is frequency dependant and is usually presented in octave or third-octave bands. On some occasions it is useful average the level in several frequency bands. The mid frequency reverberation time is the arithmetical average of the T_{60} values in the 500, 1000 and 2000 Hz octave bands.
Absorption Coefficient α	The ratio of the sound absorbed by a surface to the sound incident upon it. A value of 0 means that no sound is absorbed and a value of 1 means that all sound is absorbed. The sound absorption of a surface is frequency dependent, so it is usual to quote values of α in octave or third-octave bands
Average absorption coefficient $\bar{\alpha}$	The spatial average sound absorption coefficient of all of the surfaces within a space. The sound absorption of a surface is frequency dependent, so it is usual to quote values of $\bar{\alpha}$ in octave or third-octave bands
Noise Reduction Coefficient NRC	The Noise Reduction Coefficient is the arithmetic average of the absorption coefficient α of a material in the four octave frequency bands from 250 Hz to 2 kHz. It is a convenient way of describing the absorption performance without defining α in each frequency band.
Sabins	The effective absorption area of an object or surface in m^2. This is the total sound absorption provided by an object or surface. For an object such as a person this can be a simple value. For a surface it is the physical area multiplied by [redacted] The sound absorption of a surface is frequency dependent so it is usual to quote values of α in octave or third-octave bands

Vibration quantities

a L_a	The Vibration Acceleration is the root mean square acceleration of a vibrating body or surface its units are m/s^{2}. The Vibration Acceleration Level is the vibration acceleration expressed in decibels. The reference value a_0 is usually 1 [redacted]/s^2 (L_p in dB re 1 [redacted]/s^2)
v L_v	The Vibration Velocity is the root mean square velocity of a vibrating body or surface its units are m/s. The Vibration Velocity Level is the vibration velocity expressed in decibels. Several reference values v_0 are used for Vibration Velocity Level depending on the application. The most common are 1 nm/s for general vibration measurements and 50 nm/s for surface sound radiation measurements.
d L_d	The Vibration Displacement is the root mean square velocity of a vibrating body or surface its units are m. The Vibration Displacement Level is the vibration displacement expressed in decibels. The usual reference value d_0 is 10 pm.
ppv	The peak particle velocity is the highest velocity in any direction experienced by vibration body during its oscillation. It is measured in m/s
cppv	The component peak particle velocity is the component of the ppv in one particular direction of interest.
crest factor	The crest factor is a measure of the 'sharpness' or 'peakiness' of a waveform. It is calculated from the ratio of the peak value to the RMS value. eg. the crest factor of a vibration velocity signal is the ppv divided the RMS vibration velocity v.
W_b, W_g, W_d, W_k, W_m	Human sensitivity to vibration and the risks presented by vibration are frequency dependent. This frequency variation in sensitivity is different for different vibration axes and types of exposure. As a result, several standards, such as ISO 2631 define a range vibration frequency weightings. These are applied electronically to the measured vibration in a similar way to the A-weighting of sound pressure levels.
curve x of BS6472:1992	Another way of assessing the frequency dependent effects of vibration is to plot a vibration spectrum against a standard set of curves such as those in the 1992 version of BS 6472. Although this version of the standard has now been replaced the curves are a useful design tool and can be use in a way analogous to NR curves with sound.
VC-(A to G)	Another set of frequency dependent vibration criteria are the Vibration Criterion (VC) curves. These set limit values for a range of uses such as operating theatres and vibration sensitive equipment. The VC for a measured sound spectrum is obtained by plotting the un-weighted third-octave band vibration velocities on a set of VC curves. The VC value is the highest curve that is crossed by any one third-octave band.

VDV	The Vibration Dose Value is a measure of the total vibration experienced during a period. Its units are $m/s^{1.75}$ (or $ms^{-1.75}$) and it is defined in BS6472:2008 The VDV is based on a fourth power relationship between exposure time and exposure level. Many vibration meters are not able to measure 4th power data and can only give RMS (2nd power) results.
eVDV	The estimated Vibration Dose Value is a derived unit that gives an approximation of the full VDV using RMS vibration data where 4th power data is not available. The use of eVDV is not recommended where the vibration varies with time or where it contains impulses or shocks
A(8)	Daily noise exposure level The value is a measure of personal vibration exposure ether hand-arm or whole body. This is a product of the noise levels to which the individual is exposed and the time for which that exposure takes place averaged out over the length of a standard working day. Short duration exposures to high noise levels can produce similar personal noise exposure levels to longer exposures at lower levels. In the simplest case if a worker is exposed to a constant noise level for an 8-hour working day their personal noise exposure level will have the same value as the noise level to which they are exposed.