ACOUSTICAL CONTROL Engineers & Consultants

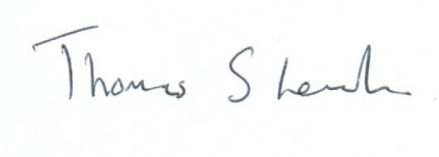
GUARANTEED SOLUTIONS TO YOUR NOISE & VIBRATION PROBLEMS

Acoustic Assessment of Proposed Refrigeration / Air-Conditioning Plant

to be Installed at

Co-op, Hugh Street, St Marys, Isle of Scilly TR21 0LL

Report Prepared by:



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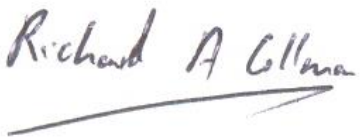

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22 July 2015

Contents

1.0 Introduction

1.1 Belair Research Limited (BRL) trading as Acoustical Control Consultants (ACC) is an independent acoustic consultancy company. All of 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.

1.2 ACC has been appointed by BJA Refrigeration Consulting Engineers Limited on behalf of The Co-operative Group (Co-op) to undertake an acoustic assessment in support of the proposals at their store at Hugh Street, St Marys.

2.0 Acoustic Environment

2.1 The store is located to the west of Hugh Town in a mixed residential and commercial area. To the north and south are the coastlines of the peninsular which extends as headland to the west of the store. Figure 2.1 shows the relative location of the store and surrounding areas.

Figure 2.1 Location of store in context of surrounding area

2.2 The store is located on the ground floor of a building with three storey extensions to the front and rear. Above the store are a number of dwellings. To the rear right of the store are a service yard and small outbuildings. To the north of the store is the coastline and marina. The area surrounding the store is a mixture of commercial and residential properties.

3.0 Proposals

3.1 As part of the proposals refrigeration plant is to be removed from the roof of the store and new plant installed in the service yard to the rear. The AC unit on the roof of the store is to be retained.

3.2 The new plant location will be approximately 10m from with significant screening to the windows of either dwellings above the store.

3.3 The refrigeration plant will be operational 24 hours per day although at night the plant will operate at a lower load either with night set-back controls or by virtue of lower ambient temperatures and the fact that cabinet doors will remain closed and night-blinds will be shut

3.4 Figure 3.1 shows the relative positions of the store (brown outline), various dwellings that may be sensitive to noise from plant, particularly during the night (green outline), and plant location (blue outline).

Figure 3.1 Store, Receptors, Plant, and Measurement Locations

4.0 Relevant Guidance & Criteria

4.1 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:

BS4142:2014 Methods for rating industrial and commercial sound

Rating Level - Background Sound Level	Initial Estimate
Around 10dB or more	Likely to be an indication of a significant adverse impact, depending on the context.
Around 5dB	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.

4.2 One of the significant differences between BS4142:2014 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.

4.3 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.

4.4 Depending upon the context and in instances where the background sound level is considered to be low, 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.

BS8233:2014 Guidance on sound insulation and noise reduction for buildings

4.5 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 8 hour night or 16 hour day time periods do not exceed 30dBA or 35dBA respectively.

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

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

4.7 There is a presumption in favour of sustainable development, which should be seen as a golden thread running through both plan-making and decision-taking. Assessments should be proportionate to the proposed development. Local planning authorities should consider whether otherwise unacceptable development could be made acceptable through the use of conditions or planning obligations.

4.8 Below the No Observed Effect Level (NOEL) sound is unnoticeable and of no significance. Below the Lowest Observed Adverse Effect Level (LOAEL) sound can be heard but does not cause any changes in behaviour or attitude, although the acoustic character of the area may be slightly changed. Below the Significant Observed Adverse Effect Level (SOAEL) sound may cause slight changes in behaviour or attitude e.g. turning up volume of a television or closing windows. There is potential for some sleep disturbance and a perceived change in the acoustic character of the area and quality of life.

4.9 Areas of Tranquillity should be protected, but in general cases it may be inappropriate to achieve a level below the LOAEL as this provides no benefit but may require additional resources such energy, materials, space, time and money, adversely affecting the sustainability of doing so. Noise above the LOAEL should be mitigated and reduced to a minimum, although it may be appropriate to exceed the LOAEL and create an adverse acoustic impact, if this provides other sustainability benefits that are of greater significance. Noise above the SOAEL should be avoided.

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

4.10 These establish that a steady level of 30dBA within bedrooms is suitable to protect vulnerable people from sleep disturbance and that occasional maximum levels of up to around 42dBA to 45dBA 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 15dBA 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

4.11 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, dBA is usually between 4 and 8 dB greater than the corresponding NR. BS8233 gives a single conversion value of 6dBA.

4.12 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.

Discussion

4.13 Extensive site experience in rural locations such as Devon, Dorset and Cornwall has shown that the typical background level is often far below what BS4142 would consider "low" and therefore appropriate to use for an assessment.

4.14 Due to the limited relevance of BS4142 in these environments Acoustical Control Consultants have previously agreed with all three local authorities that absolute noise levels based on alternative guidance would be suitable in protecting both the health and amenity of nearby receptors. It is therefore proposed that a similar approach is taken for this site whilst also reflecting the context of the local environment.

4.15 National Planning Policy recognises that development may affect amenity but clarifies that any such impact must be within acceptable limits. There may be no benefit in achieving conditions below the Lowest Observed Adverse Effect Level (LOAEL) because this is unlikely to provide any additional benefit, but have other adverse effects on the sustainability of the development.

4.16 Guidance such as BS8233, and guidance from the World Health Organisation identify that during the daytime period a level of around 35dBA inside the closest noise sensitive receptors above the store is likely to be suitable to properly protect residential amenity. This equates to an external sound level of 45dBA.

4.17 At night, a steady level of around 30dBA inside bedrooms is suitable to protect residents from sleep disturbance. With open windows this can be achieved if the external sound level is around 40dBA or lower.

4.18 From discussions with environmental health officers for the Council of the Isles of Scilly it is understood that there is no adopted policy relating to noise but that any application would need to protect residential amenity.

5.0 Assessment

5.1 Plant will be operational during the day and night. The reference time interval (T_r) is 1h during the day (0700-2300 hours) and 15min during the night (2300-0700 hours). In reality the plant 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.

Selected Plant

5.2 The following plant has been selected, located and will be attenuated (if necessary) to achieve suitable sound levels at the closest sensitive receptors, consistent with the previously identified criteria.

Arctic Circle CPCHU5SE-086-MT-S

5.3 Manufacturers' acoustic data for the proposed equipment is shown in Appendix 2. Plant manufacturers generally state sound emissions from their plant as either a sound power level or sound pressure level at a defined distance of for example 1m or 10m. This data allows sound levels at distance from the plant to be calculated.

Acoustic Feature Correction

5.4 BS4142 provides specific guidance regarding a Rating Penalty if sound from the plant will contain characteristics that could attract a listener's attention at the noise receptors. This is a subjective assessment and logically should be assessed at the listening position of the closest receptors not an arbitrary point close to either plant or receptor.

5.5 Extensive site experience has shown that the Arctic Circle unit is likely to contain low frequency acoustic characteristics where running at part load therefore a 2dB rating penalty has been applied to reflect this. When running at full capacity the character of the plant is controlled by noise from the fans which is relatively broadband and would not attract a listener's attention considering the context.

Plant Assessment

5.6 Calculation Sheet 1 in Appendix 1 shows how the sound pressure level produced at noise sensitive receptors is calculated from the selected plant acoustic data, taking account of separation distance, reflective surfaces and other significant factors appropriate to this specific analysis.

5.7 When considering the context of this assessment i.e. plant to the rear of a foodstore in a rural town location, a Rating Level of 31dBA due to the plant will not disturb neighbouring residents and will be consistent with both National Planning Policy and will be at least 10dB below relevant authoritative guidance. There is therefore likely to be no acoustic impact associated with this.

5.8 At night, the primary concern is to ensure that residents will not be disturbed by the level or character of sound from plant at the store, whilst avoiding the potential adverse sustainability consequences of trying to achieve an unnecessarily low level that provides no additional benefit. Authoritative guidance such as BS8233 and the World Health Organisation indicates that a Rating Level of up to around 40dBA outside the nearest dwellings will be consistent with these objectives.

5.9 When considering the context of this assessment and the acoustic environment during the night-time period, a Rating Level of 28dBA due to the plant will not disturb neighbouring residents who may be sleeping with open bedroom windows and will be consistent with National Planning Policy and will be around 10dB below the levels presented in relevant authoritative guidance. There is therefore likely to be no acoustic impact associated with this.

5.10 The level from the selected plant will be significantly below the levels presented in relevant guidance from BS8233 and the WHO. Considering the context of the local environment and that new plant will be moved further away from the closest receptors compared to the existing refrigeration plant it is considered that there will be no adverse impact to the nearby receptors. This is therefore consistent with the aims of the local authority.

5.11 Table 5.1 below details a full assessment of selected plant considering the context of all current authoritative guidance.

Results	Daytime	Night-time
BS8233:2014 guidance	35dBA cumulative indoors equating to 45dBA outside internal receptors	30dBA cumulative indoors equating to 40dBA outside internal receptors
NPSE guidance		LOAEL 40dBA outside internal receptors
World Health Organization	35dBA cumulative indoors equating to 45dBA outside internal receptors	30dBA cumulative indoors equating to 40dBA outside internal receptors
Local Planning Authority guidance	No adverse impact	No adverse impact
Recommended level	Not to exceed a cumulative level of 45dBA	Not to exceed a cumulative level of 40dBA
Rating level	31dBA	28dBA
Difference between rating and recommended levels	-14dB	-12dB
Assessment	Indication of no adverse impact	Indication of no adverse impact

Table 5.1 Assessment

5.12 The outcome of the assessment 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 store 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, or inside bedrooms at night, assuming that windows may be open for ventilation where this is applicable.

Uncertainty

5.13 Annex C provides further information regarding the causes and effects of Uncertainty in an acoustic assessment such as this.

5.14 Any acoustic analysis such as those in Calculations Sheet 1 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.

5.15 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 Rating Penalty, 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 Rating Penalty, it is possible to considerably reduce this level of uncertainty. The plant manufacturers are also aware that it is their responsibility to ensure that the plant complies with their stated performance and that should this not prove to be the case, they will be responsible for treating the plant so that it does then comply. An additional margin of safety is provided by assuming that all plant that may operate at the time being considered (day time or night time) may simultaneously be operating at maximum capacity for that time. In reality, it is likely that only some plant will be operating at maximum capacity at any time, as a result of which the actual sound level produced by the plant will be slightly lower than assumed for assessment purposes.

6.0 Conclusions

6.1 A cumulative level of 45dBA outside the nearest dwellings during the day and 40dBA at night will ensure that the neighbouring residents are not disturbed by noise from plant at the store.

6.2 Existing refrigeration plant is to be replaced with new plant located further away and with significant screening to the nearest residential receptors.

6.3 The proposed plant will produce Rating Levels of 31dBA during the day and 28dBA outside the nearest dwellings at night to ensure that the neighbouring residents are properly protected from disturbance due to noise from the plant. This is also consistent with a range of authoritative guidance, local and national planning policy. It is considered that the proposed plant will have no adverse impact.

Appendix 1 Calculation Sheets

Calculation Sheet 1 - Analysis of Proposed Plant

Daytime calculation

			CPCHU5SE-086-MT-S	UNIT 2	UNIT 3	UNIT 4
Sound Power Level			**61 dBA**			
Corrections	Distance from plant to receptor	10m	-28 dB			
	Acoustic Screening	Significant	-10 dB			
	Plant location character	Corner	+6 dB	N/A	N/A	N/A
	Directivity	In front	+0 dB			
	Acoustic feature correction	Slight Tonality	+2 dB			
	Attenuation		+0 dB			
Sound Pressure Level at Receptor			**31 dBA**	**0 dBA**	**0 dBA**	**0 dBA**
					Cumulative Sound Pressure Level at Receptor	**31 dBA**

Night-time calculation

			CPCHU5SE-086-MT-S	UNIT 2	UNIT 3	UNIT 4
Sound Power Level			**58 dBA**			
Corrections	Distance from plant to receptor	10m	-28 dB			
	Acoustic Screening	Significant	-10 dB			
	Plant location character	Corner	+6 dB	N/A	N/A	N/A
	Directivity	In front	+0 dB			
	Acoustic feature correction	Slight Tonality	+2 dB			
	Attenuation		+0 dB			
Sound Pressure Level at Receptor			**28 dBA**	**0 dBA**	**0 dBA**	**0 dBA**
					Cumulative Sound Pressure Level at Receptor	**28 dBA**

Appendix 2 Plant Data Sheets

ACOUSTICAL CONTROL Engineers & Consultants

arctic circle

Plant Specification

Quote Number	1129 A (1)
Customer	BJA Refrigeration
End User	The Co-operative Group
Site	Isle of Scilly
Date	01/06/2015

Type of Equipment	Ultra Low NoiseCondensing Unit
Model No.	CPCHU5SE-086-MT-S
Quantity	1

Design Parameters		
	LT	*MT*
SST (°C)	-	-10
Design Duty (kW)	-	48.88
Refrigerant	-	R407A
Condensing (°C)	-	43
Ambient (°C)	-	35
Super Heat (K)	-	20
Suction Return Temp (°C)	-	-
Useful Super Heat (K)	-	10
Sub Cooling (K)	-	5

Compressors

Compressor Manufacturer		*Copeland Scroll*							
		LT	*Inv*	*Digital*	*Sound Shell*	*MT*	*Inv*	*Digital*	*Sound Shell*
Compressor Models	*Comp 1*					ZB45			✓
	Comp 2					ZB45			✓
	Comp 3					ZB45			✓
	Comp 4					ZB45			✓
	Comp 5					ZB45			✓
	Comp 6								
	Comp 7								
	Comp 8								
	Comp 9								
	Comp 10								

Performance

Nominal Evaporator Capacity	*LT (kW)*	-
	MT (kW)	50.5
FLA	*Amps*	93.9
DRA	*Amps*	74.2
LRA	*Amps*	74
THR	*KW*	72
Mass Flow	*g/s*	342

**For Illustration Purposes Only*

Physical

Intended Location		External
Dimensions	*(L) x (D) x (H) mm*	4003 x 1130 x 2287
Weight	*kg*	2250
Sound Pressure Level Free Field	*dB(A) @ 10m*	30 Full Load , 27 Part Load
Sound Power Level Free Field	*dB(A)*	-
Colour RAL		7032
Access		Front
Services		Top Right
Primary Control		RDM
Back Up		Siemens Logo
AV Mounts		Not Included
Liquid Receiver Capcity	*Litres (L)*	46
Liquid Receiver Location		Within Housing
Liquid Receiver Orientation		Horizontal
Oil Type		Solest 31 HE

Condenser

Condenser Supplied		Included
Location		Attached to Unit
Fan Type		EC
Number of Fans		2

Notes

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 This edition of the Standard 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 Rating Penalty

Synopsis

B.1 A Rating Penalty 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 Rating Penalty 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 Rating Penalty unless agreement cannot be reached, in which case the objective/ reference methods may be appropriate alternatives.

B.4 Whilst the maximum Rating Penalty could arguably be 15 dB or possibly even 18 dB, in reality it is expected that, where a Rating Penalty 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. BS4142 provides guidance regarding how a rating penalty 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 rating penalty for representative conditions but to then consider the range of variation of potential rating penalty 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 perceptibl*e'.

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 rating penalty 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 rating penalty 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 Rating Penalty, 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 BS4142 aims 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 BS4142: 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 rating penalty 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 BS4142 assessment.

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. BS4142 considers 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 rating penalty 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.

Rating Penalty Uncertainty

C.22 The rating penalty 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 BS4142.

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 rating penalty and to clearly explain how this has been arrived at. The uncertainty in the magnitude of the rating penalty 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 BS4142 assessment 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 BS4142 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 BS4142:2014 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, BS8233 indicates 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 NPPF and NPSE 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.

BS4142:2014 Methods of rating industrial and commercial sound

D.4 BS4142:2014 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 BS8233:2014 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 rating penalty 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 BS4142 requires 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.

BS8233:2014 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 BS8233 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 BS8233 is derived.

Annex F Competence & Experience

F.1 Belair Research Limited has the advantage of personnel that were directly involved in the drafting of the original 1967 edition of BS4142 and the most recent 2014 edition, 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 Collman** has specialised in acoustic engineering for half a century and was the founding director of Belair Research Limited (BRL) in 1981. He was seconded onto the BSI committee that drafted the original 1967 version of BS4142 and has been involved in the assessment of sound from industrial and commercial plant since then. He pioneered the consideration of sustainability as part of acoustic assessments rather than simply assessing the level and character of noise in isolation.

F.3 **Richard A Collman** now has overall responsibility for BRL's activities including BS4142 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 BS4142, presented the section on Uncertainty at the BS4142 Launch Meeting in November 2014, and authored an associated Technical Article in Acoustics Bulletin. He has been closely involved in the development of BRL's BS4142 measurement, assessment and reporting system to ensure that it is fully compliant with all aspects of BS4142.

F.4 **Lee Dursley,** Senior Acoustician has specialised in the measurement and assessment of sound from commercial and industrial sites for over 10 years. He has a BSc(Hons) in Engineering Physics, a Post Graduate Diploma in Acoustics and Noise Control and is a corporate member of both the Institute of Physics and the Institute of Acoustics. With day to day responsibility for BRL's consultancy activities he has been significantly involved in the development of the measurement, assessment and reporting systems to ensure that they are compliant with the requirements of the latest version of BS4142.

F.5 **Thomas Leach** has a BSc (Hons) in Sound Technology from the University of South Wales, a MSc in Sound and Vibration Studies from the Institute of Sound and Vibration Research, University of Southampton and is currently an associate member of the Institute of Acoustics. Thomas has been an acoustic consultant for nearly 5 years, primarily focused in environmental acoustics for which he has undertaken assessments in accordance with BS4142.