ANC | ACOUSTICS & NOISE CONSULTANTS

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BS 4142:2014+A1:2019
Technical Note

This Technical Note has been prepared by members of the Association of Noise Consultants Good Practice Working Group.

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This is intended to be a discussion document with some qualified views from the ANC Working Group (WG) and should not be taken as a prescriptive guide. The discussion is also intended to assist with the evolution and development of subsequent guidance.

The following sectional titles are those of BS 4142:2014+A1:2019 and reflect the content therein.

Introduction

BS 4142:2014+A1:2019 is the latest iteration of a standard which was first published in 1967, designed to consider the effects of industrial sound with appropriate consideration to the character of that sound as well as its level.

The basic premise of that approach remains in BS 4142:2014+A1:2019 but its scope is wider than that of its predecessors in terms of the noise sources and assessment scenarios to which it applies. It is also more detailed and significantly longer than earlier versions, even without its appendices.

All subsequent references to "BS 4142" are to BS 4142:2014+A1:2019 unless stated otherwise.

The 2014 edition of the standard was replaced with an amended version in 2019, the former having been withdrawn. The amended standard was published to improve clarity, to correct errors and improve the consistency of the assessment of the impacts.

Prior to publication of the 2014 edition, there was a contentious consultation stage which included questions on the:

- Methods to assess tonal and impulsive character;
- Proposed linear addition of character penalties;
- Risk of using the phrase 'significant adverse impact' given its wider meaning in policy;
- Onerous nature of full compliance with BS 4142 methodology;
- Expense of meteorological monitoring; and
- Lengthening of the night time reference period.

These areas, and others, remain concerns for some users of BS 4142 and this guidance is designed to assist readers with a reasonable interpretation and application of BS 4142 as a whole.

In the production of this guidance, the ANC Working Group (WG) has reviewed BS 4142 and attempted to address any content regarded as ambiguous. There are some instances where the WG has chosen to go beyond strict interpretation of BS 4142 and to offer additional ancillary advice. Wherever possible a group position has been presented. In some cases, where the WG has held a range of views, it has tried to make this clear.

The WG has tried to illustrate the guide with real life examples, some of which were provided by working group members and some of which were helpfully provided by other ANC members. In certain sensitive cases, where the group felt it necessary to alter the reported facts, it has tried to do so without changing the principles on which the assessment decisions and outcomes were based.

The discussion within the document is also intended to assist with the evolution and development of BS 4142 and accompanying guidance.

Finally, there are many instances in the application of BS 4142 where professional judgement is required and where a range of interpretations is possible. This guide is not intended to be definitive or prescriptive but is offered as a resource from which the reader may access the views of the members of the WG, which complement BS 4142 itself.

Notes

Quotes from BS 4142 are presented in inverted commas and bold typeface.

All references to industrial sound include commercial sound.

All references to dwellings include premises used for residential purposes.

The document follows BS 4142 in layout and numbering. The WG has made comments on the text in each section where appropriate, where it was felt that the text was clear and sufficient then no additional guidance has been added.

This guidance sets out the unanimous view of the WG unless there was disagreement, in which case this is stated.

Clarification on the status of British Standards

Legal Context

With a very few exceptions, standards do not have force of law: the application of a standard is almost always voluntary, although standards are very often used in support of legislation, and compliance with a standard is sometimes quoted in legislation as offering a route to discharging legal obligations.

Responsibility of standards users

It is the responsibility of all users of standards to select standards which are in all respects appropriate to their needs and that they use the standards and the product (including service) to which they relate in a safe and appropriate way.

Foreword

The meaning of **'appropriately qualified and experienced'** (paragraph 8) could vary depending on the nature of the assessment. In general, it is taken to be 'An individual who holds a recognised acoustic qualification and membership of an appropriate professional body'[1]. Such people should normally be at least MIOA and/or with significant experience in the relevant field of acoustics. For simple assessments (such as a single plant item), this could be AMIOA or TechIOA, but under the close supervision of an appropriately qualified and experienced practitioner. Registration of employer consultancies with the ANC would be an appropriate way of demonstrating the appropriate level of organisational experience.

It is of particular importance that readers understand the 'presentational conventions' within BS 4142.

1. Guidance/requirements of BS 4142 are presented in roman (i.e. upright) type, and any recommendations are expressed in sentences in which the principal auxiliary verb is "should".
2. *Commentary, general informative explanation and accompanying material are presented in smaller italic type.* - These are not mandatory requirements of BS 4142 and are presented only as guidance of BS 4142's Drafting Committee. The practitioner may use the recommendations contained therein or may, with justification presented, use other methods.

1 BREEAM UK New Construction 2018, Non-domestic Buildings (United Kingdom), Technical Manual: Version: SD5078

1. Scope

The phrase **'industrial and/or commercial nature'** (Subclauses 1.1, 1.2(a), 1.2(b)(2)) has two separate limbs which can be interpreted in their own right. For example, sound of an **'industrial nature'** need not be associated with a commercial venture or activity to be within the scope of BS 4142. Conversely, sound generated by a commercial activity need not necessarily conform to any narrow definition of **'industrial'** to be within the scope of BS 4142.

It was the majority view of the WG that BS 4142 could be applied in certain domestic scenarios involving sound sources of an industrial nature such as condensers, compressors, air handling units and boilers.

Garden amenity value was considered to be much reduced in the night-time period (suggested in BS 4142 as 23:00 to 07:00 hours) and the focus of protection should be on amenity at the residential accommodation itself during this period. It is suggested that this view would hold relevance to the contextual stage of an assessment.

The phrase **'on or around an industrial and/or commercial site'** (Subclause 1.1(d)) is considered to extend to haul roads within a site boundary. Where a site access road is not in the exclusive ownership of the industrial/commercial operator BS 4142 can be used unless more appropriate standards apply (e.g. DMRB)[2].

Similarly, sound from mobile plant within the confines of a dock, marina or similar could be considered using BS 4142 whilst sound from waterways would fall outside the scope.

For example; Subclause 1.3 of BS 4142 states:

"Sound of an industrial and/or commercial nature does not include sound from the passage of vehicles on public roads and railway systems"

There may be circumstances where this seemingly clear exclusion is not adhered to. For example, it might be reasonable to undertake a BS 4142 assessment of sound from heavy goods vehicles using a public road that passes close to houses, and only serves those houses and an industrial site. Consequently, it has little traffic on it for large parts of the day and night other than the industrial heavy goods traffic.

If the heavy goods vehicles use refrigeration equipment, which is more similar in nature to an item of industrial plant than a heavy goods vehicle, and/or may be parked on the road for extended periods, a BS 4142 might be considered reasonable.

This might not be the conclusion reached if the road were more heavily-trafficked, so that the heavy goods vehicles were not so prominent in the context of the acoustic environment.

However, in all instances, it is for the assessor to justify their decision.

The phrase **'premises used for residential purposes upon which sound is incident'** (Subclause 1.1) should be interpreted as encompassing a building used for residential purposes together with land within the residential curtilage. Where assessment locations are external areas of low amenity value, in remote areas of large gardens for example, then this can be taken into account in the contextual discussion; more than one assessment might be warranted in such circumstances. The WG interpreted 'residential' broadly and felt that this should include 'rooms for residential purpose'[3].

2 Design Manual for Roads and Bridges, Highways England

3 "room for residential purposes" means a room, or suite of rooms, which is not a dwelling-house or flat and which is used by one or more persons to live and sleep in, including rooms in hotels, hostels, boarding houses, halls of residence and residential homes but not including rooms in hospitals, or other similar establishments, used for patient accommodation.

The direct determination of noise amounting to a nuisance is outside the scope of BS 4142 (Subclause 1.3) as nuisance is determined on a case-by-case basis by the Courts and the relevant considerations are far broader than those covered by BS 4142. However, an assessment made using BS 4142 could form a useful component of a nuisance assessment and its relevance should not therefore be discounted entirely.

A strict reading of the scope suggests that sound sources of an industrial nature which are integral to **'recreational activities'** (Subclause 1.3(a)) could be excluded from the scope. However, pragmatically, such sources can be assessed using BS 4142 if the sound character is broadly commercial or industrial in nature and that an assessment using BS 4142 can, therefore, be justified. On that basis, the following examples can be assessed using BS 4142 if the sound character justifies it and an assessment using BS 4142 is reasonable:

- A marina for leisure boats where a diesel-powered winch pulls boats up a slipway;
- A paragliding club where gliders are launched by a diesel-powered mobile winch; and
- A generator providing power to a recreational activity centre, such as a scout hut.

The majority view of the WG was that the test for exclusion of **'domestic animals'** (Subclause 1.3e) is applied to the setting rather than the type of animal. Animals kept on domestic premises are therefore considered to be beyond the scope of BS 4142 whilst the same animals in a commercial setting could, in theory, be within the scope, e.g. a kennel. A minority view held that BS 4142 should only apply to sound of an industrial nature and would not cover domestic animals in any setting.

For **'other standards and guidance'** (Subclause 1.3(h)) to render a situation outside the scope of BS 4142, the relevant standard or guidance should be widely recognised (preferably a British Standard or Government-endorsed, for example) and applicable to the circumstances of the assessment.

BS 4142 **'is not intended to be applied to the assessment of indoor sound levels'** (Subclause 1.3) and cannot, therefore, be used for façade design. Whilst BS 4142 can be used to assist in the determination of the likelihood of an adverse or significant adverse impact, guidance on internal design criteria and mitigation is provided elsewhere. BS 8233:2014[4], for example, provides guidance on indoor ambient noise levels, although recognition should be given to the associated scope and/or limitations.

BS 4142 does not define **'assessment location'** within the definitions set out in Clause 3 but states to **'use outdoor sound levels'** (Subclause 1.1) and is **'not intended to be applied to the assessment of indoor sound levels'** (Subclause 1.3). Furthermore, in the numerous references to the **'assessment location'** throughout BS 4142 the inference is that it is an external location. The determination of character correction relies on acoustic features being **'present at the assessment location'** (Subclause 9.1) and therefore, at the external measurement location.

BS 4142 states **'The Standard is not applicable to the assessment of low frequency noise'** (Subclause 1.3) and NANR45[5] is referenced in this connection. Sound referred to as low frequency in NANR45 is energy within the 10 – 160 Hz frequency range. The WG considered that BS 4142 does not necessarily exclude such a wide range. It would be reasonable to use BS 4142 down to 50 Hz and possibly lower as part of a tonality assessment, for example.

In connection with this:

- It would generally be inappropriate to remove low frequency content from data sets;
- Where low frequency sound clearly arises from the assessment site it could be considered as part of an assessment (see Annexes C and D of BS 4142);
- BS 4142 is not applicable to ground borne low frequency sound;
- Where low frequency noise is the dominant component of the specific sound source, the applicability of BS 4142 should be carefully considered and justified if necessary;
- Care should be taken when identifying sources (at Section 4) that low frequency sources are correctly apportioned; and
- BS 4142 should not be used, even if an assessment is requested, for example by a regulator or client, in a situation that is considered to be inappropriate.

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

5 NANR45 Procedure for the assessment of low frequency noise complaints, University of Salford for Defra

2. Normative References

The WG did not see any requirement to provide additional guidance on this Clause.

3. Terms and Definitions

As discussed above; the phrase **'assessment location'** is not specifically defined in Clause 3 or elsewhere in BS 4142. It is made clear within BS 4142 that the assessment location is an external location (Subclauses 1.1, 1.2, 6.2, 7.1, 7.3, and 8.1).

The **'assessment location'** will often be in an external residential amenity area such as a garden or balcony although it may, by necessity, be representative of an exposed residential façade where no such external amenity exists. Assessment locations should reflect the actual usage of the residence or associated amenity area. This may mean that assessment locations are within the main amenity area but not necessarily at the boundary.

Where internal impacts are the prime concern, the height and orientation of windows should be considered when measuring or otherwise deriving sound levels externally. Free-field equivalent levels should normally be cited and used in the assessment unless circumstances dictate otherwise.

Subclause 3.4 and the note to Subclause 3.5 state **'...quoted to the nearest whole number of decibels'**. Decibel levels should be quoted to the nearest whole number but the calculation or derivation of the specific and background sound levels should be based on the precision/accuracy of the instrument and then rounded to the nearest whole number.

'Reference time interval, T_r' (Subclause 3.8). The WG wishes to emphasise that the given time interval does not apply to the determination of background sound level. The time interval used to determine the background sound level should be in accordance with guidance given in Section 8 of this document and Clause 8 of BS 4142.

Definitions of Specific, Residual and Background

'Specific Sound Source' (Subclause 3.12) is described as **'sound source being assessed'**.

'Residual sound' (Subclause 3.9) is defined as the **'ambient sound at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound'**.

'Background sound level' (Subclause 3.4) is defined as the L_{A90} of the residual sound.

The identification of the specific sound source, and by implication the residual sound, is a fundamental element of the application of BS 4142 which should take place as early in the assessment process as is practicable.

In many circumstances, it may be clear as to what constitutes the specific sound source, and therefore what forms the residual sound environment. Examples might include new or replacement plant proposed close to existing residential properties, or where a complaint relates to a particular identifiable source. In these circumstances, the new installation or the complained-about plant is the specific sound source, and everything else can be regarded as part of the residual sound environment.

However, in some circumstances, it may not be immediately obvious, for example where new residential development is proposed close to a commercial/industrial site that contains multiple sources, or close to a commercial/industrial area with multiple premises, or where an existing source is one of many similar sources affecting an established residential area.

It is incumbent on the assessor to clearly define which source(s) constitute the specific sound source(s) and, by implication, the residual sound sources, as this will dictate how BS 4142 is implemented. All of the measurements and analyses that form part of the assessment will be predicated on these decisions.

The WG discussed at length various scenarios where different interpretations of what might be considered the specific sound source would affect the scope, nature and outcome of the assessment.

The biggest area of concern was where new residential development is proposed close to existing industrial/commercial sources, particularly where the industrial/commercial sites operate constantly and continuously. There is a risk that underestimating the contribution of legitimate commercial residual sources to the

background sound level could potentially lead to unrepresentatively adverse outcomes.

The fourth paragraph of the notes to Subclause 8.1 states that existing industrial or commercial sources can be included in the background sound level; as long as they are separate to the specific sound.

BS 4142 is clear that the residual and background sound sources/levels should not include any contribution from the specific sound source. Given this requirement, background sound measurements may involve measuring during periods where the specific sound source is switched off, or using a comparable alternative measurement location (as allowed under Subclause 8.1.2). When selecting an alternative location it should be subject to reasonably comparable residual sound contributions as the assessment location.

However, the note to Subclause 8.5 states ***'Where a new noise-sensitive receptor is introduced and there is extant industrial and/or commercial sound, it ought to be recognized that the industrial and/or commercial sound forms a component of the acoustic environment. In such circumstances other guidance and criteria in addition to or alternative to this standard can also inform the appropriateness of both introducing a new noise-sensitive receptor and the extent of required noise mitigation.'***

Where BS 4142 is used in this situation, its fundamental principles, in terms of what constitutes the residual, background and specific sources, should not be compromised.

Where other standards or guidance document are used, care should be taken with regard to their own stated scope or limitations. Examples of such guidance might include:

- BS8233: 2014 where an industrial/commercial sound source is constant and new residential development is proposed nearby;
- Elements of ProPG[6] where the impact of regular night time maximum sound events is the critical consideration;
- DMRB where impacts relate solely to changes to vehicular movements within or around a site; or
- BS 5228[7] where activities are temporary and of a similar nature to the construction activities considered by that Standard.

These documents, or others, may help to inform the contextual elements of a BS 4142 assessment or help where a numerical assessment fully in accordance with BS 4142 may not be possible.

6 ProPG Professional Practice Guidance on planning and noise: New Residential Development, ANC/IOA/CIEH

7 BS 5228:2009 Code of practice for noise and vibration control on construction and open sites.

4. Preparation

The WG felt that Clause 4 of BS 4142 was overly brief and it was therefore considered that additional guidance, as provided in the following paragraphs, would be useful. In common with many other areas of BS 4142, the amount of preparation required should be proportionate to the nature and scale of the assessment.

Where applicable, it is preferable that the programme of measurements and procedure should be agreed with the Local Authority or other overseeing body prior to carrying out the work.

When planning the survey, the location and nature of nearby noise-sensitive receptors (NSRs) should be considered, as should the existence of other sound-generating sources that are not part of the assessment and may affect the background or residual sound levels measured.

The underlying purpose of the measurements sshould be kept in mind: to quantify the specific sound level of the source if it is in place by measuring the ambient and residual sound levels; and to obtain as realistic a measurement as possible of the background sound level at the potentially-affected NSRs.

The planning of the measurements should take into account potential sources of error and uncertainty so that these can be minimised. A discussion of the means taken to do so should then be included in the uncertainty section of the assessment. The consideration of uncertainty should be a continuous process from beginning to end of the assessment.

If measuring sound from existing items of mechanical plant or some other process or activity, ensure so far as is reasonable that this process will be operating during the survey. This confirmation may require communication and discussion with the site operations manager or owner and it may be necessary to have the plant turned on and off during the survey process. In the case of service yard or vehicular activity, it may be necessary to arrange for demonstration examples of typical activities to be made and a time log of normal operation be provided so that the specific sound level can be calculated.

The WG has considered each item listed in Clause 4:

'a) identify and understand all the sounds that can be heard, and identify their sources'

This process will generally begin with a desktop assessment using tools such as mapping, aerial/birds eye photography, street view images and a review of information such as plans, prior reports and consent documents. Discussions with those with first-hand knowledge of the location can also be very useful – those might include; residents, business operators, co-professionals and local authority officers or members.

A site visit informed by earlier research is more likely to account for remote, concealed, mobile or dormant noise sources which may not be readily apparent on casual inspection. Local knowledge will be particularly important where there are significant time-varying sources which might be missed during a single visit, for example some industrial operations are cyclic, seasonal or demand-led.

Local noise sources within residential curtilages such as boiler flues, pumps or fans may be unobtrusive whilst off (whilst residents are at work for example) but might significantly affect residual and background measurements if instruments are sited close to them. Where unattended measurements are relied upon it can therefore be useful to study time history graphs in conjunction with audio samples to ensure that the sources contributing to the measured levels are understood and apportioned appropriately. This is particularly important where the data is to be used for proxy locations. Multiple assessments may be necessary.

'b) identify which measurement methods, instruments and metrics (see Clause 5) would be most appropriate for the assessment'

The majority of instruments in common usage which meet the instrumentation specifications of Clause 5 of BS 4142 are capable of logging multiple parameters, logging periods, and frequency spectra.

Practical considerations which may inform choice of equipment, however, include:

- Dynamic range;
- Instrument power options for longer-term measurements;
- Instrument security for unattended deployments;
- Microphone mounting options for atypical monitoring locations (e.g. façade or above ground floor);
- Microphone weather protection and wind shield types;
- Availability of audio recording and triggers if required;
- Need for and capability of meteorological monitoring equipment;
- Time synchronisation of all logging equipment;
- Logging periods for sufficient analysis options;
- Logging parameters required, e.g. are objective/reference methods likely to be needed; and
- Memory capacity and download options.

Where feasible and appropriate, it is recommended that sufficient data is captured to allow more detailed analysis to be undertaken should it prove necessary thus potentially avoiding the need for repeat deployments.

The nature and degree of the uncertainties associated with the equipment (including both sound and meteorological equipment) and measurement choices should be considered and minimised as part of the selection process. These considerations should be reported in the uncertainty section.

'c) identify potential measurement locations'

The potential measurement location(s) should be identified following stages (a) and (b) above and with consideration to:

- The reason for the assessment, e.g. a complaint;
- The location of the impact, e.g. garden/indoors;
- Physical characteristics, e.g. reflective surfaces, barriers, local noise sources;
- The relationship of the location to the noise source(s) under investigation. For example
  - is there an unobstructed line of sight to the source(s),
  - are there significant reflections unique to the location which might make it unsuitable for proxy assessments,
  - are multiple sources equidistant or at varying distances away; and
- Whether a single measurement location is not suitable as a proxy for all assessment locations and multiple measurement locations are necessary.

It is reiterated that measurement locations should always be external even though the assessment might be used to assess the effect on people inside a premises used for residential purposes, as described in Subclause 1.1.

Where the primary effect under consideration is inside a building, the location and sensitivity of the rooms, as well as the transmission pathways through the building envelope, should be considered in the choice of external monitoring location. For example, where the façade facing the specific sound source has no openings it might be appropriate to measure outside another façade.

Where a window to a habitable room overlooks the sound source, the use of an elevated façade measurement location could be appropriate if practical.

For example; a bedroom may overlook a plant compound which has an acoustic barrier. A measurement location 1.2-1.5m above ground level may benefit from screening but the bedroom window might not. An elevated measurement position representative of the bedroom window could be more appropriate.

'd) identify the necessary measurement frequencies, durations and timings'

These are important considerations to enable **'typical'** and **'representative'** conditions to be captured and understood by the assessor; **'measurement frequencies'** should be interpreted as the number of measurements and not the spectral content of measurements.

The measurement frequencies, durations and timings may be dictated to some extent by the scale and nature of the assessment. If sound sources are highly time variable, but unpredictable, protracted unattended monitoring or a higher number of shorter attended deployments may be the only practical options for observing or measuring representative conditions over time.

The timing of visits or measurements should be informed by some prior knowledge of the source to be assessed. It may be necessary to demonstrate that different times of the day and night have been evaluated.

Fundamentally, these matters must be considered if all on/off conditions, or potentially numerous combinations of operational activities, are to be adequately quantified.

In addition to the appropriate quantification of background, residual and ambient sound levels, sufficient coverage of monitoring and observations is also important to enable a full contextual consideration. Contextual assessments are not restricted to the three key areas identified in Clause 11 of BS 4142 but should also consider factors such as when, how often and for how long the sound source(s) under investigation occur. In the absence of this information from an alternative source, it may need to be derived from the measurement regime.

Where monitoring data is likely to be used as an input or verification point for an acoustic model, the nature of the required acoustic model inputs and outputs should be considered before monitoring is commenced. Under these circumstances, the choice of monitoring locations, durations and timings may be dictated by the need to ensure that monitoring data is directly comparable with the model. Where measurements are being made to quantify a sound source as a model input, the monitoring location will need to be close enough to the source to minimise the influence of other, unrelated, sound sources.

'e) where a new development is to be assessed, understand what kind of sound a new industrial and/or commercial source would introduce, or what potential impact would be imposed from an existing source on a new sensitive receptor'

Where a new development is proposed, but not yet delivered, as much information as possible should be obtained regarding the development, to minimise the number of assumptions that are relied upon, and therefore the uncertainty. Any remaining assumptions should be considered within the uncertainty assessment (see Section 10 of this document).

In the case of the introduction of new sound source(s), as much information about the source, its siting and operation as possible should be obtained from the developer. If sufficient data is unavailable from the developer to underpin a robust assessment, it may be necessary to make informed judgements about the likely sound levels and character based on observations and measurements at similar existing installations. Under these circumstances, particular care should be taken to consider the differences in the proposed installation and its relationship with receptors and with the background and residual sound environment.

Where BS 4142 refers to understanding the **'potential impact'**, this refers to the types of impact which might occur such as; sleep disturbance, speech interference, diminution of the value of external amenity. For this purpose it is necessary to understand the nature of the sound sources under consideration.

In summary;

The level of preparation required prior to the assessment may vary considerably depending on the nature and complexity of the assessment. Furthermore, the complexity may not be proportionate to the scale of the assessment, or related to the specific sound source, but may simply result from a complex acoustic environment comprising numerous unrelated and dynamic sound sources with varied propagation pathways and receptor types.

For example; an assessment may be planned for a single fixed speed, continuously operated industrial fan on a relatively flat commercial site with few buildings and a direct line of sight to a single residential receptor. This might appear to be a straight forward assessment. However, given the importance of the background, residual and contextual considerations in an assessment, it is possible for complexities to arise from external influences. The background sound level may be highly varied necessitating protracted monitoring and statistical analysis. Weather effects may significantly influence background and residual sound level contributions. Contextual considerations may require protracted research and the relevant factors may appear contradictory leading to difficulties deriving their relative importance.

Generally, the WG considered that both pre-visit and on-site preparation were important and likely to add to the value of field work and that the amount of resource invested in preparation should be proportionate to the nature and scale of the assessment.

For example; the assessment of a single steady noise source at one receptor would require little preparation and fewer considerations than an assessment of a multi-component industrial facility with many receptors and in proximity to multiple sources of interference. In the latter case, significant research would be required before the assessment and effective discussion with operators and residents on site is likely to be key.

5. Instrumentation

The equipment requirements should be proportionate to the nature and scale of the assessment to be undertaken. The potential uncertainty inherent in the equipment selection should be considered and noted for the uncertainty discussion.

5.1 General Requirements

Subclause 5.1 of BS 4142 sets out conformance requirements for measurement instrumentation, including microphone(s), cable(s), windscreen(s), recording devices and other accessories that have to be met:

- Sound level meters: BS EN 61672-1[8], Class 1 (for free-field application, as appropriate);
- Octave and fractional octave filters; BS EN 61260-1[9], Class 1, and
- Sound calibrators: BS EN 60942[10], Class 1.

The use of BS EN 60804, Type 1, and BS EN 60651, Type 1 instruments was allowed by the 2014 version but this is no longer the case following the 2019 amendment; Type 2 instruments are not permitted under either version.

5.2 Verification

Note 1 to Subclause 5.2 recommends that sound calibrators are calibrated at intervals not exceeding 1 year, conformity of the measuring systems to BS EN 61672-1 is verified at intervals not exceeding 2 years, and the conformity of filters to BS EN 61260 is verified at intervals not exceeding 2 years. It is also acceptable to verify measuring systems in accordance with BS 7580-1.

BS 4142 does not explicitly state that instrument calibration be carried out by laboratories with UKAS accreditation but only requires that valid certificates showing conformity to each relevant standard (traceable to national standards).

Paragraphs 4.33 to 4.34 of the ANC Pre-completion Testing (PCT) Handbook Version 13.0 November 2018 states that SLMs and calibrators should be subject to traceable calibrations every two years with field calibrators subject to additional cross checks after a year.

Subject to appropriate procedures and record keeping, the WG endorses the ANC approach which facilitates the pairing of SLMs with dedicated calibrators.

With respect to pairing of calibrators and sound level meters, BS EN 61672 requires that at least one model of sound calibrator be specified for checking and maintaining the correct indication of the display at the calibration check frequency. Significantly, it is a requirement of BS EN 61672 that if a sound calibrator from a different manufacturer is to be used, the applicable microphone correction data must be known.

8 BS EN 61672-1 Electroacoustics. Sound level meters. Specifications

9 BS EN 61260-1 Electroacoustics. Octave-band and fractional-octave-band filters. Specifications

10 BS EN 60942 Electroacoustics. Sound calibrators

6. Measurement Procedure

The measurement procedure should be planned prior to leaving for site and be appropriate for the scale of assessment to be undertaken.

Clause 4 of BS 4142 covers good practice in preparation before leaving for site and reference should be made to that and Section 4 of this document when planning the survey and measurements, including:

- Number of positions and type of equipment;
- Survey duration;
- MET data source;
- Local Authority Liaison;
- Location of NSRs and other noise generating plant;
- Potential sources of error and uncertainty;
- Ensuring the subject plant is operating if necessary and can be turned and on off if required; and
- Risk Assessments.

During the survey, the underlying purpose of the measurements should be kept in mind, e.g. to quantify the specific sound level of the equipment, if it is in place, by measuring the ambient and residual sound levels; and to obtain as realistic a measurement as possible of the background sound level at the potentially affected NSRs.

Where the planning of the measurements has taken into account potential sources of error and uncertainty so that these can be minimised, then the appropriate measures should be taken on site to control these. However, the planning stage of the assessment process can only take into account reasonably foreseeable events and the surveyor should still be aware of the potential for variance or unexpected events/conditions and react accordingly.

The consideration of uncertainty should be a continuous process from beginning to end of the assessment and this process must be fully documented in the final report.

Consider whilst carrying out the survey how the survey report will be written, make explicit notes of all sound sources apparent on site including photos if possible and video clips[11] if appropriate. Similarly, describe and assess all relevant NSRs and consider the sound transmission paths to each significant one.

In the case of service yard or vehicular activity, it may be necessary to arrange for demonstration examples of typical activities to be made and a time log of normal operation be provided so that the specific sound level can be calculated.

When arriving at site, consider the risk assessment and determine if there are additional hazards that should be considered. In all cases, the surveyor should put their safety and the safety of others first.

11 The assessor should recognise audio bandwidth and compression limitations of video recording devices and judgements about implementation of BS 4142 should be made with caution if at all. Generally, video footage and its component audio can be useful as an aide memoir but should not form part of a quantitative assessment.

6.1 Field Calibration Check

BS 4142 sets the acceptable field calibration drift to ±0.5 dB for attended measurements. Any drift beyond these limits results in data being questionable, and it should only be used with great caution.

The WG recommends that in addition to the sound level measuring equipment having a field calibration check before and after the measurement survey, one should also be carried out when appropriate during the survey, for example when the equipment has been powered down and back on again.

If equipment has been on-site for an extended period, or shipped, then a visual inspection and cross calibration with other equipment of known status should be considered.

If survey equipment has been exposed to unfavourable weather over a significant period, possibly months, then it may be appropriate to increase the calibration frequency.

Reference should also be made to the guidance in Annex B of BS 4142.

There is no reference to specification, calibration or verification of meteorological (MET) instruments. Given that the primary purpose of the meteorological monitoring detailed in Subclause 6.4 is to record conditions close to the microphone, rather than to assist with the assessment of propagation effects, the WG considered that a high degree of accuracy was not essential or implied by BS 4142.

6.2 Measurement Locations

Whilst the positions of sound measurement locations will have been planned as part of the preparation, consider on site whether they are the most appropriate locations and be prepared to adapt if necessary. Access may not always be possible to planned locations and alternative locations may be required.

The WG considered that the use of the word 'will' in the first paragraph of Subclause 6.2 may be inappropriate as even the most ideal monitoring locations may not yield the desired results in practice. The selection of suitable measurement locations is a matter for careful professional judgement and absolute statements about measurement results are potentially misleading.

Similarly, if the acoustic climate is affected by an unforeseen sound source, it may be necessary to find an alternative, equivalent location.

Free-field equivalent levels are preferred at the assessment location but 'façade' position measurements may be necessary in some circumstances and the note provides advice for adjusting these values. In some circumstances, different adjustments might be appropriate for different sound sources and or measurement locations.

Care must be taken so that comparisons are made between equivalent sound levels, such as between free-field values. Some situations where this might apply include:

- where a proxy background sound measurement is in free-field conditions and the rating level is derived from a specific sound measured at a façade location; or
- where a background sound level is measured as a façade value but the specific sound level is derived from free-field measurements or manufacturer's data;

in which case one of the values should be adjusted so they are equivalent.

An assessment under reverberant or semi-reverberant conditions has a greater uncertainty due to the variabilities in reflected energy arising from the noise sources contributing to the specific, residual and background levels.

Care should be taken with microphone mounting techniques when setting up unattended measurements. The microphone should be orientated appropriately. The equipment should be safely mounted and cables stress relieved.

Further good practice guidance including guidance on site health and safety is also given in the ANC Green Book[12].

12 ANC Guidelines 'Environmental Noise Measurement Guide' ISBN 978-0-9572543-3-6 or subsequent update (in development at time of writing)

6.3 Precautions against Interference

In addition to the guidance in BS 4142, consideration should be made of other potential sources of interference, common sources include:

- Wind and rain affecting nearby foliage;
- Birdsong; and
- Passers-by.

With regards to item (a) of Subclause 6.3, the WG notes that large or secondary wind shields are available which reduce the interference of wind passing over the microphone.

In addition, the porosity of the windshield is an important factor. Literature[13] suggests that for windshields of circa 90mm diameter when used with a ½" microphone and with porosity values in the range 20 to 60 PPI, optimum reduction in wind noise occurs at a porosity of around 40 PPI.

All precautions taken should be reported and potential interference effects included in the uncertainty discussion.

6.4 Weather Conditions

The purpose of Subclause 6.4 is to enable an assessment of local meteorological influences or interferences at the measurement location, rather than to understand propagation effects; high precision measurements are not essential. For attended sound measurements, a hand-held anemometer and compass should be sufficient for a practitioner to adequately record weather conditions at the beginning of the survey and additionally as necessary.

For unattended measurement locations, the need for a co-located MET station should be assessed on a site-by-site basis. It will not always be practical nor is it considered essential where, for example, the site is reasonably open and reliable representative data is available from a credible alternative source. The reliability and applicability of externally sourced MET data should be considered in the uncertainty assessment.

Subclause 6.4 could also be read to imply that a MET station is required at each measurement location; it is the view of the WG that one MET station is likely to be sufficient per assessment site provided that the conditions are considered representative of all the measurement locations.

In some circumstances, a single position attended sound survey with manually noted MET information may be appropriate, for example when considering a small ventilation unit affecting a limited number of receivers. More normally, unattended measurements over several days at one or two positions would be appropriate with logged MET data or a reliable third-party weather data source.

In larger or more complex scenarios, where data from a single MET station may not represent weather conditions at all measurement locations, several MET stations may be required.

13 On the wind noise reduction mechanism of porous microphone windscreens. J. Acoust. Soc. Am. 142 (4), October 2017

7. Specific sound level

There could be, in certain circumstances, significant potential for confusion in deciding what components of industrial/commercial noise should be assessed as part of the specific sound and what should be treated as part of the residual and or background sound level. The reason for the assessment must be considered in making this judgement.

1. Investigating complaints. The sound source may be singular or comprise multiple components (e.g. **'all noise from a commercial premise or operation'**). The specific sound source(s) should be identified by, or following discussions with, the complainant. If the complaint relates to non-compliance with a planning or permit condition, the sound source in question may be identified in the condition.
2. When assessing sound from existing sources, the sound source may also be singular or comprise multiple components (e.g. **'all noise from a commercial premise or operation'**). The specific sound source(s) is defined by the scope and purpose of the assessment and will be identified on a case by case basis.

   For example,

   i. if there is a planning condition, the specific source may be identified in the condition;

   ii. if an existing industrial facility wishes to quantify the potential impact of their operations then the specific source may result from all of their operations or only individual items of plant.
3. Assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature. The specific sound will arise from the operation of the new or modified sound source(s). The rating of an existing sound source which is being modified or replaced, should be considered in the long-term against the prevailing background sound, however, the contextual discussion could refer to the source that was modified or replaced if the specific sound has reduced.

   For instance, the new or modified source may be quieter than the one it is to replace:

   - The WG considered that it would generally be inappropriate to include the sound from the old source in the residual/background level of the assessment of the new source;
   - However, there may be a sound reduction following the replacement and this may be an important consideration in terms of context;
   - Ideally, an assessment of the original source and a separate assessment of the new source would inform the contextual discussion drawing out the benefit of the reduced sound level from the new or modified source.

   The contextual assessment could include quantification of all the previous sound sources. Where this is not possible, for instance because the previous sources have already been removed or are otherwise non-operational, their relevance should be evaluated considering:

   - The amount of time since the operation of the original sound sources ceased;
   - The amount of time the original sound sources had been operational;
   - Whether the original sound sources were lawful;
   - Whether the original sound sources had attracted noise complaints; and
   - That failure to recognise the noise contributions of redundant/obsolete sources risks unfairly penalising quieter replacement plant or improved working practices.
4. Assessing sound at new dwellings or premises used for residential purposes proposed close to existing industrial or commercial sources. Clause 7 of BS 4142 does not define how to determine which industrial/commercial sources should comprise the specific and residual sound levels respectively for this scenario. This is discussed within Section 3 of this document.

8. Background Sound Level

8.1 General

The start of Subclause 8.1 is a five-paragraph commentary that sets out some general context for Clause 8 of BS 4142.

The first three paragraphs provide general advice and contextual information that is expanded upon within the main text of Clause 8.

The fourth paragraph in the commentary in Subclause 8.1 indicates that existing industrial or commercial sounds can legitimately be part of the background sound climate, if they are separate to the specific sound. This ties back in with the definitions in Clause 3 of BS 4142, where the background sound level is defined as the $L_{A90,T}$ of the residual sound, which is in turn defined as the ambient sound in the absence of any specific sound.

By definition, the background sound level should not include any contribution from the specific sound source. As is set out later in this section, this is a critical matter in the use of BS 4142 in some circumstances.

The final paragraph relates to common-sense meter management.

It was the view of the WG that it is not always appropriate to define a singular background sound level for use in an assessment. In such cases, a range of values over one or more time periods may be more appropriate. An assessment should generally focus on the sound levels measured during the period of greatest interest, which may be the quietest part of the night, or the time period relating to a complaint. Determining the period of greatest interest should be judged on a case-by-case basis.

Simple Assessment

One method the WG considered to be suitable for determining the background sound level for a simple assessment is to undertake sound measurements encompassing the period of greatest interest and to switch on or off the sound source as appropriate during this period. This may not always be possible, and should be considered carefully e.g. consider whether there is a run-up time for the equipment to reach full operating power.

Complex Assessment

An alternative approach, considered by the WG to be suitable for a more complex assessment, would be to undertake longer-term monitoring over several days. A range of values may then be selected based on the period of greatest interest. Where a significant amount of data has been obtained, statistical analysis of the levels recorded over the period of greatest interest may be appropriate.

The WG agreed that the histogram approach given in Figure 4 in BS 4142 has the potential to be misleading if not applied carefully. For example, it would generally be considered inappropriate to simultaneously consider sound levels within the same histogram which relate to wholly different time periods (e.g. daytime and night time). This is considered particularly true if there is significant difference in level between these periods.

In practice, a range of approaches to the derivation of background sound levels should be considered as part of a complex assessment and the relevance and applicability of the derived values discussed. The time history, mean and mode values over the period(s) of interest would ordinarily be considered but no one method is always applicable. The assessor should use their professional judgement to evaluate a representative value in each situation.

BS 4142 is not prescriptive about the length of background sound measurement periods, only noting that the duration used should be adequate to represent the situation but not normally less than 15 minutes. This does not preclude measurements of less than 15 minutes, but where shorter measurements are taken, justification should be presented.

In this context, any measurement time interval is considered acceptable under the terms of BS 4142, providing the assessor can justify that it appropriately represents the background sound climate.

It is important to understand the distinction between measurement time interval and measurement logging period, or resolution. Detailed analysis of events that occur during a particular measurement can be greatly assisted if a short logging period is used, for example 100ms, thereby allowing particular events to be analysed more closely. However, where short logging periods are used, the facility should exist to combine such periods into an overall measurement time interval that represents the situation, e.g. a 15 minute period suggested by BS 4142.

Subclause 8.1.1 steps through the different approaches to be taken in certain situations (Subclauses 8.1.1 (a) to (e), which cross-refer to Subclauses 8.2 to 8.5).

Subclauses 8.1.2 to 8.1.5 apply to all situations, as they are listed in the 'general' section, prior to each of Subclauses 8.2 to 8.5. Therefore, alternative measurement positions (Subclause 8.1.2), measurement time interval (Subclause 8.1.3), measurement duration (Subclause 8.1.4), and consideration of what sources are present (Subclause 8.1.5) are considered to apply irrespective of which of Subclauses 8.2 to 8.5 are implemented.

Subclause 8.1.2

Subclause 8.1.2 covers the use of alternative locations where it is not possible to measure at the assessment location. The choice of alternative locations should be justified with as much detail as is considered necessary to explain why it is considered acoustically similar to the assessment location.

It is self-evidently important to get the choice of location as right as possible, but it is recognised that a 'perfect' location is unlikely to be available in most instances. It is therefore important to consider and explain the effect or consequence of how the alternative location might differ from the assessment location. As far as it possible, this should be factored into the consideration of uncertainty.

Subclauses 8.1.3 and 8.1.4

The WG view is that the duration, timings and conditions required to determine representative background sound levels should be assessed and justified on a case-by-case basis. If unattended measurements are to be relied on, then the importance of the assessor understanding the nature of the area and the relative contributions to the sound level has greater importance. If attended measurements are used, then the duration should be sufficient to determine a representative level. In practice, a combination of attended measurements and observations, and longer-term measurements are likely to yield the most robust data.

Where largely unattended measurements are to be relied upon, the importance of investigating local sources of interference is particularly important. Within a residential curtilage there may be a number of steady sound sources which are not immediately obvious during instrument deployment. These can include boiler flues, mechanical ventilation, air/ground source heat pumps, kitchen extraction etc. which might not be operating during the working day but have significance during evening and weekend periods. Whilst such sound sources might be legitimate components of the background sound level at the measurement location, this might not hold true at locations to which the background level is applied by proxy.

Longer duration measurements are less likely to be unduly influenced by non-continuous steady sources (such as thermostatically controlled plant).

Conversely, measurements should not generally extend beyond any discrete periods of interest. For example, under some circumstances an assessment may relate to evening periods only, in which case the background measurement used should generally relate only to that period. However, it is recognised that there may be instances where extending measurements beyond a discrete period of interest informs understanding of how the background sound level changes, and could be useful in understanding the limitations of a particular measurement window. An example might be where a measurement just before the start of the daytime period provides an understanding as to how the daytime background sound levels might vary under different circumstances.

Notes to Subclause 8.1.4:

The notes to Subclause 8.1.4 contain some highly relevant information that should inform the approach to quantifying the background sound level, although the information is not a formal requirement of BS 4142.

Note 1 makes it clear that the choice of representative background sound level is not a simple matter of identifying a minimum or modal value over a particular period, but recognizing that several periods of measurement may be necessary and that a more thorough analysis of the data is normally required.

Note 2 states a mathematical fact, but understanding of this fact is important in how background sound level surveys are planned, executed and analysed.

Note 3 is superficially a simple statement, but the implications can be wide-ranging. Background sound level measurements should be undertaken in appropriate meteorological conditions, and potentially repeated across a range of meteorological conditions.

The WG is concerned that the generally accepted limitation of sound measurements to wind conditions <5m/s may result in an underestimation of background sound levels in areas with high wind speeds where the background sound levels are largely determined by weather conditions. It is common practice to avoid measuring, or to discard data recorded, whilst these higher wind speeds are evident even though they may legitimately contribute to the background sound levels for a significant proportion of the time.

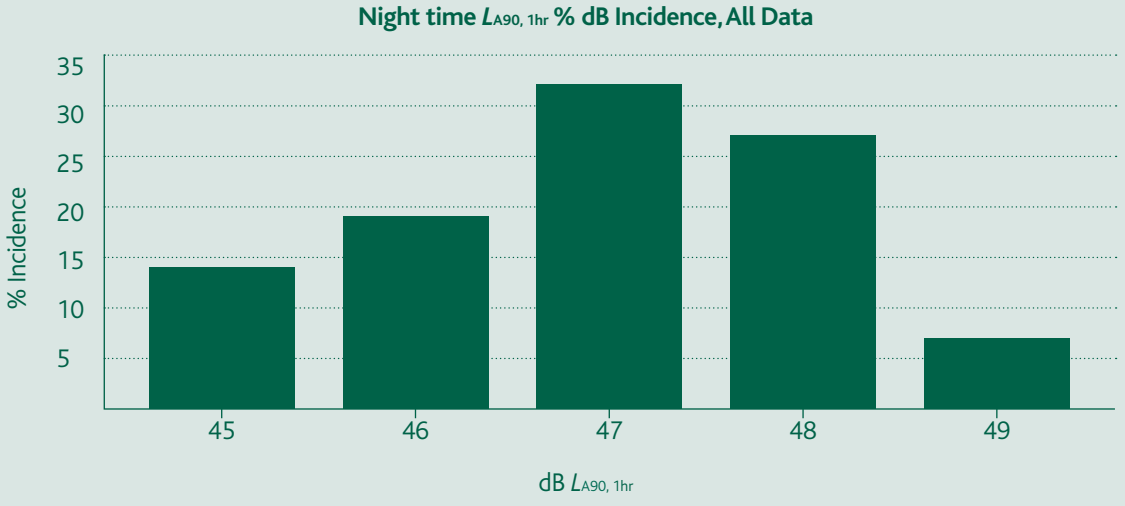
Experience with wind farm noise assessments has demonstrated that background sound levels can be accurately measured at higher wind speeds and that, in the absence of other dominant sound sources, wind induced sound can be the primary determinant of background sound levels.

Care should be taken in circumstances where the background sound levels do appear to be dictated by meteorological conditions. For example, at windy sites it may be inappropriate to exclude all wind-affected data from analyses as these might comprise a legitimate part of the data set. If sound data gathered during higher wind speeds is to be used, suitable wind shields should be fitted in accordance with advice provided in the Institute of Acoustics *Good Practice Guide for the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* 2013. Information about the long-term wind conditions for a site should be provided and discussed to justify the use of higher wind speed data.

Example

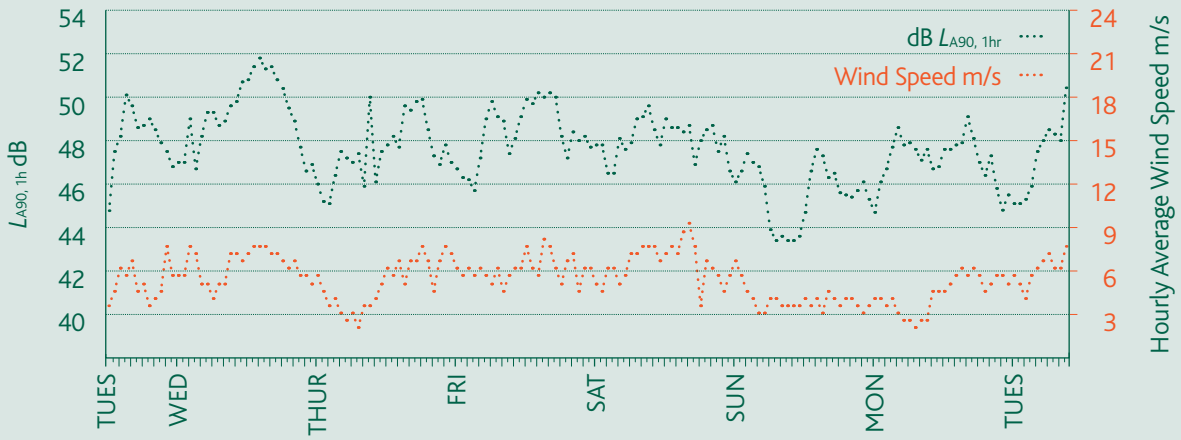
A week-long baseline survey was undertaken at a potential residential development site adjacent to a variety of commercial and industrial uses. The site, which was close to a major river estuary, was frequently subject to windy conditions. Attended measurements suggested that the night time L_{A90} level was dictated by steady plant noise during calm weather conditions but that wind induced noise may be influential at times.

The cumulative distribution of L_{A90},1h values based on all of the data logged between 23:00 and 07:00 showed a relatively narrow range with a mode of 47dB.



By plotting the time history of the L_{A90} data and the hourly average wind speed together on the same graph, it can be seen that higher wind speeds do have a relationship with the logged L_{A90} levels.

Background Sound Level $L_{A90, 1h}$ dB and Wind Speed m/s



When data with wind speeds in excess of 5m/s are removed prior to analysis, the re-plotted cumulative distribution has twin modes, one of which is a lower value of 45dB.

Night time $L_{A90, 1hr}$ % dB Incidence, MET Exclusions

This type of information can help to underpin and justify a balanced decision on the choice of background sound level(s) adopted in an assessment. In this example, a review of the weather patterns over a number of years indicated that the conditions during the survey were not atypical for the area and, on that basis; the wind affected data were retained in the analysis and in this instance, a value of 47dBA was taken to be representative.

However, the analysis recognised that background sound levels are lower during calm conditions and, at such times, potential impacts from industrial/commercial sources may be greater; this could be included in the contextual discussion.

Note 4 provides an explanation of an example as to how a particular representative level might be inferred from a particular set of data, in this instance, presented in the form of a statistical analysis histogram.

The WG felt that the identified representative number was not necessarily the most appropriate value, and that a figure of 35dB might be more representative, based on the presented information. The use of an example where the identified representative background sound level is not an obvious value is unhelpful.

A number of further examples are presented below, whereby time history, histogram and cumulative distribution data for a number of real-world examples are presented, along with the range of values selected by the WG as being representative.

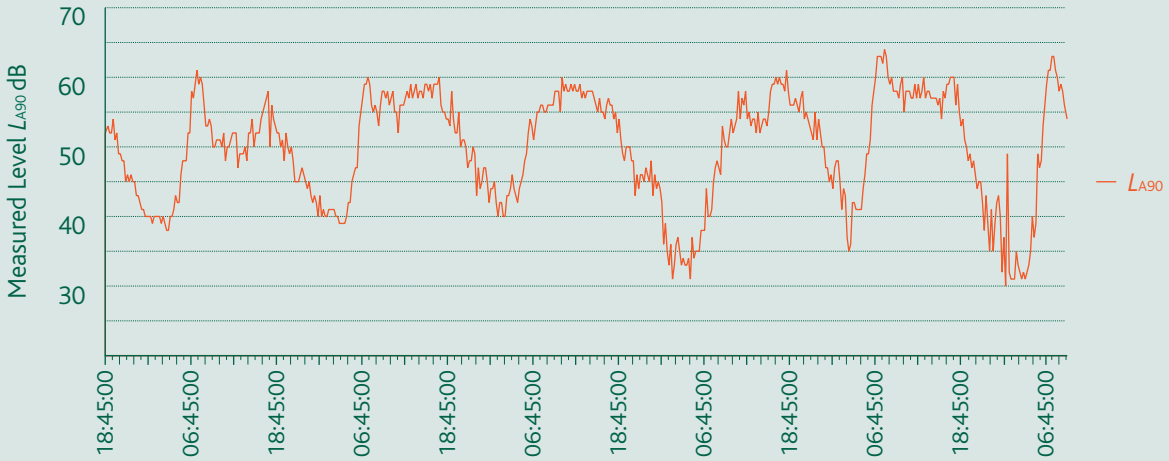
These examples are included to illustrate the range of views in the WG as to how best to identify representative background sound levels for particular datasets and serve to highlight the sensitivity of the outcome to individual interpretations of measurement data.

It must be remembered that there are no 'correct' answers, only judgement and justification. In many instances, additional information beyond that presented in these examples would be required to inform the judgement of representative levels.

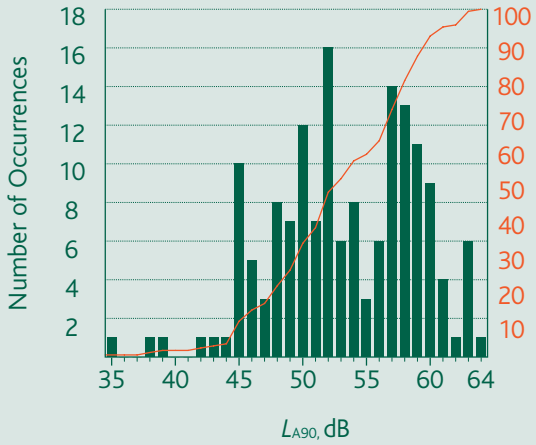
Example: Position 1 - Rural area, adjacent to an A-road.

The key sound sources at the monitoring location included traffic on the adjacent road, distant traffic from major roads some distance away was audible in gaps between cars on the nearby road or when that traffic dropped off, distant trains were just audible. Other sounds included natural sources, such as rustling trees and birdsong.

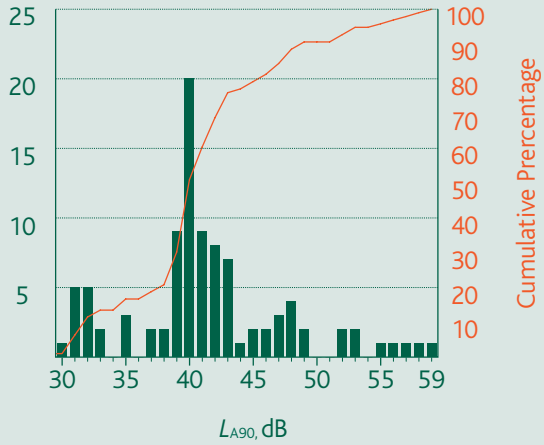
Position 1 - Time History



Position 1 - Daytime



Position 1 - Night-time

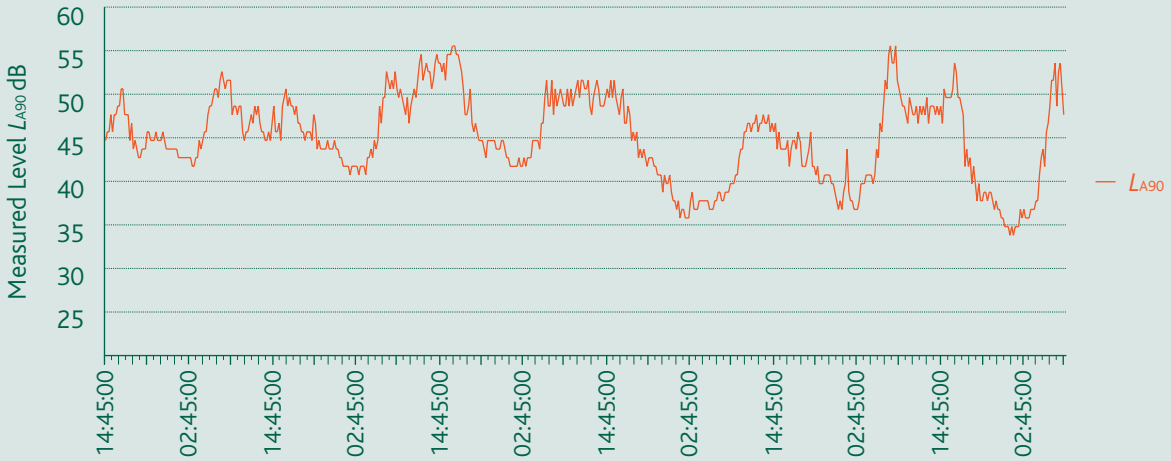


	Daytime	Night-time
Range	35-64	30-59
Mean	53	41
Mode	52	40
Representative Value, as judged by WG	45 to 52 (Most commonly selected value: 45)	38 to 40 (Most commonly selected value: 40)

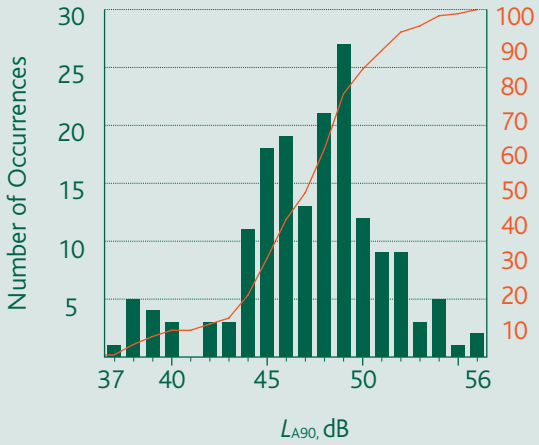
Example: Position 2 - Rural area, close to a minor road.

The key sound sources at the monitoring location included sporadic and intermittent traffic on the adjacent minor road, and sound from distant roads. Other sounds included natural sources, such as rustling trees and birdsong.

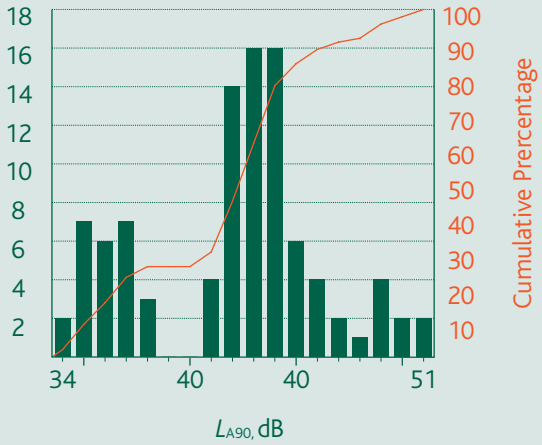
Position 2 - Time History



Position 2 - Daytime



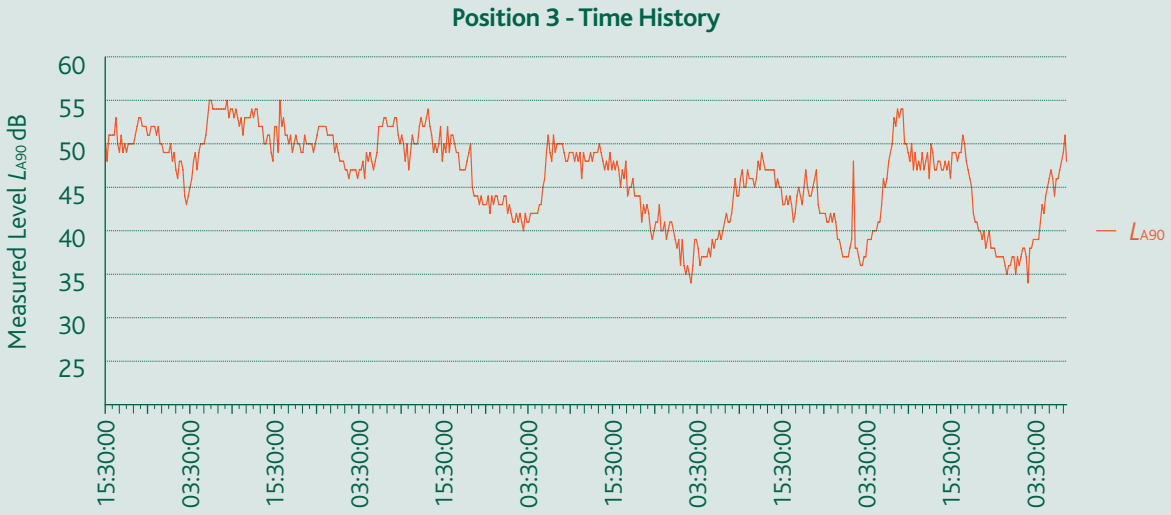
Position 2 - Night-time

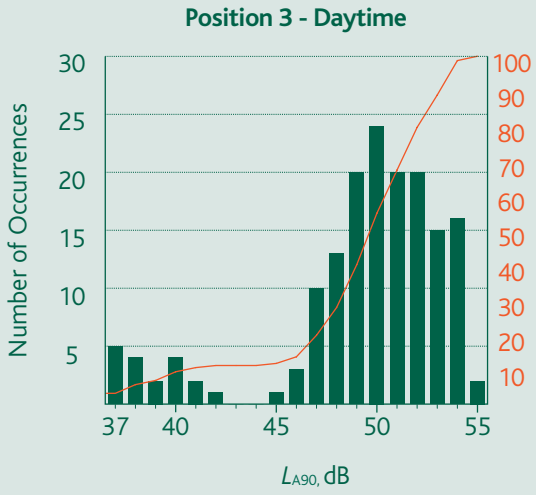


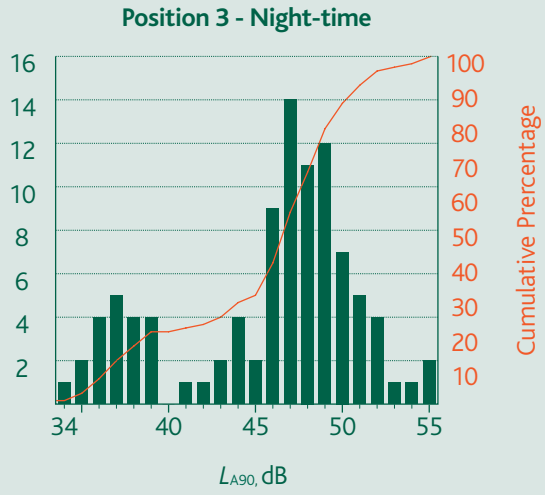
	Daytime	Night-time
Range	37-56	34-51
Mean	47	42
Mode	49	43
Representative Value, as judged by WG	44 to 48 (Most commonly selected value: 44)	35 to 43 (No commonly selected value by WG)

Example: Position 3 - Rural location, close to a minor road, with a major motorway approximately 300 metres away in a cutting.

The key sound sources at the monitoring location included sporadic and intermittent traffic on the adjacent minor road, and sound from the motorway. Other sounds included natural sources, such as rustling trees and birdsong.







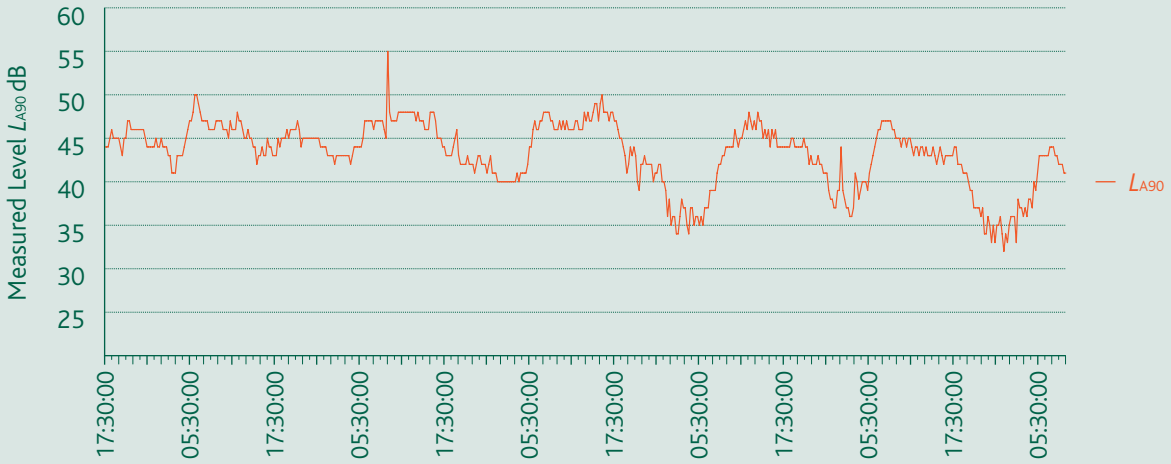
	Daytime	Night-time
Range	37-55	34-55
Mean	49	46
Mode	50	47
Representative Value, as judged by WG	40 to 50 (Most commonly selected value: 47)	37 to 47 (Most commonly selected value: 37)

Example: Position 4 - Edge of housing in a semi-rural setting.

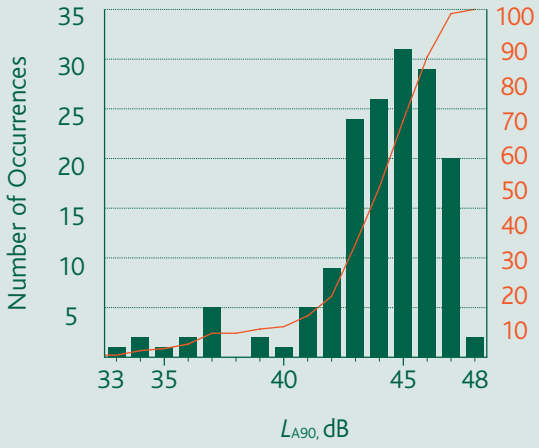
Monitoring location is approximately 300 metres from a major mainline railway line, with a major motorway and A roads also in reasonably close proximity. A small copse of trees is located approximately 20 metres away.

The key sound sources at the monitoring location included train noise, and sound from road traffic on the various nearby roads. Other sounds included natural sources, such as rustling trees and birdsong.

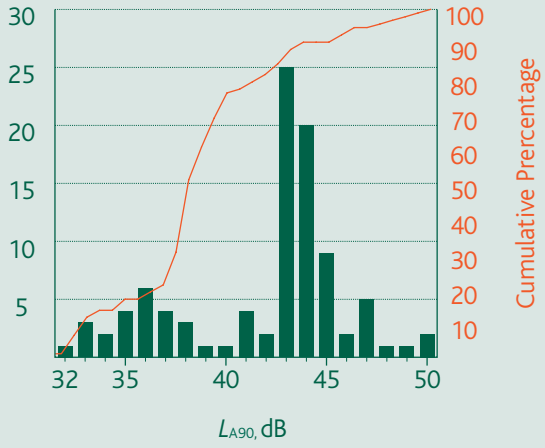
Position 4 - Time History



Position 4 - Daytime



Position 4 - Night-time



	Daytime	Night-time
Range	33-48	32-50
Mean	44	42
Mode	45	43
Representative Value, as judged by WG	37 to 45 (Most commonly selected value: 42)	36 to 43 (Most commonly selected value: 36)

Subclause 8.1.5

This subclause requires no additional commentary.

8.2 Proposed, new, modified or additional specific sound source(s)

This scenario is considered to be the most straight-forward typically encountered when implementing BS 4142. The absence of the specific source means it should be easy to establish the background sound level without influence from the specific sound source.

It is still important to undertake the background sound level measurements in the correct manner, taking account of the advice in the remainder of Clause 8.

Existing legitimate industrial or commercial sources of sound that are present may be considered as part of the background sound climate.

8.3 Existing specific sound source(s) not operating continuously

This scenario is more complex than that covered by Subclause 8.1, but with appropriate advance planning and adjustment on the ground during a survey, it should be relatively straight-forward to identify the periods when the specific sound source is not operating, and undertake background sound level measurements accordingly. If circumstances dictate, an alternative monitoring location may be used as covered by Subclause 8.1.2.

Existing legitimate industrial or commercial sources of sound that are present when the specific source is not operating may be considered as part of the background sound climate.

8.4 Existing specific sound source(s) operating continuously

This scenario makes use of the 'alternative location' provision in Subclause 8.1.2. As noted previously, it is important that the alternative location is as acoustically similar to the assessment location as is possible, except for the absence of the specific source.

Existing legitimate industrial or commercial sources of sound that are present at the alternative location may be considered as part of the background sound climate, but they should only be present to the same extent as they are at the assessment location.

8.5 Introduction of a new noise-sensitive receptor

This scenario is the most complex and generated more discussion within the WG than almost any other aspect of BS 4142.

There were extensive discussions around what constituted a legitimate source for the background sound level as a result of the extended commentary, both in Subclause 8.1 and in Subclause 8.5, as the WG sought to interpret what had been intended when the standard was drafted.

Whether or not, and to what extent, existing commercial/industrial activities should be included in the background sound measurement is likely to be a particularly important consideration where such sources exist.

The WG considered that, legitimate industrial/commercial sound from other premises in the vicinity of the source under investigation could generally be included in the determination of background sound levels, but any contribution from the specific source should be avoided.

The consideration becomes more complex when there are multiple sound sources audible at the assessment location from the same or nearby premises. Identification of what might be considered the specific source(s) in those circumstances becomes critical. In the absence of a complaint or proposed new source, this identification may be left to the assessor, in which case the reasoning behind his or her decision should be explained in the report.

It is important that the assessor clearly describes the relationship between the sound sources which are the subject of the assessment and those which are a legitimate part of the underlying soundscape for the purposes of both residual and background level determination.

The note to Subclause 8.5 identifies the use of other guidance and criteria in addition to or alternative to BS 4142. This should not be taken to mean that the underlying principles of BS 4142 can be compromised within an assessment made under that standard. Other criteria may be considered, perhaps as part of the contextual element of the assessment, or instead of the BS 4142 assessment. Care should be taken when referring to other guidance or criteria that they are not implemented beyond their own terms of reference.

9. Rating Level

Clause 9 of BS 4142 describes procedures for applying acoustic **'character corrections'** to account for certain characteristics present in the specific sound source. These **'character corrections'** reflect the prominence of the characteristic features within the sound which can result in a greater impact than that suggested by a basic comparison between the specific sound level of the source and the background sound level. For example, a sound with prominent impulses may attract more attention than continuous sound without impulses with the same equivalent sound pressure level.

BS 4142 states that there are three approaches for deriving these **'character corrections'**, set out as the:

a) subjective methods;

b) objective method for tonality (one-third octave method);

c) reference methods.

It is noted that the objective method only applies to the one-third octave method for tonality and as such there are only two methods available for impulsivity. There are only subjective methods for intermittency and 'other sound characteristics'. Reference methods are also referred to as objective methods in BS 4142, and are listed under the **'Objective methods'** Subclause 9.3.

BS 4142 states that, where the subjective method is insufficient, the one-third octave method and/or reference methods should be used as appropriate. On this basis the subjective method is the first method that should be employed.

It should also be noted that BS 4142 refers to **'character corrections'** and **'rating penalty'** in different clauses for the same thing and they are used interchangeably in the following.

Subjective Method

Subclause 9.2 of BS 4142 describes the subjective method and states:

'Where appropriate, establish a rating penalty for sound based on a subjective assessment of its characteristics'

The WG considered that the use of the word 'subjective' in this context is unhelpful as all methods should be employed 'objectively' in the broader sense of the word and there should be no inference that this is an inferior method. The subjective method takes a largely qualitative approach to defining a number, whereas the objective and reference methods are purely quantitative approaches.

Subclause 9.2 further advises that:

'This would also be appropriate where a new source cannot be measured because it is only proposed at that time, but the characteristics of similar sources can subjectively be assessed'

The method requires that **'character corrections'** are applied to the specific sound level if a tone, impulse or other characteristic occurs, having regard to **'the subjective prominence of the character of the specific sound at the noise-sensitive locations and the extent to which such acoustically distinguishing characteristics will attract attention'**.

It is important to note that the judgement is to be made at the assessment location; the presence of a character feature at source does not necessarily mean there will or should be a character correction applied in the assessment.

When applying the subjective method, it is clearly necessary to fully understand the definition of tone and impulse to help to minimise misallocation of **'rating penalties'**.

In simple terms, a tone may be defined[14] as a:

a) Sound wave, the instantaneous sound pressure of which is a simple sinusoidal function of time;

b) Sound sensation characterised by its singleness of pitch.

Some practitioners have found it helpful as a field test for tonality, to consider whether the component of the sound could be hummed or whistled.

An impulse is defined at Annex E.3 of BS 4142 as:

'The sudden onset of a sound'

The use of the word **'impulse'** is potentially confusing as sounds that may not be typically considered to be impulsive may be judged as impulsive in BS 4142. This is in contrast to the 1997 version of BS 4142 where impulses were described as **'bangs, clicks, clatters or thumps',** all of which are typically short duration events.

For the purposes of the subjective method considering impulsive **'character corrections'**, the practitioner should attempt to identify the audibility and prominence of 'sudden sounds', rather than what may or may not be defined as an 'impulse' sound by other definitions, including that in the 1997 version of BS 4142. This is based on the NOTE to Clause E.3 which states **'the definition includes only the onset of a sound, not the sound as a whole'**. In these terms, the sound can therefore be considered to justify an **'impulsive' 'character correction'** even if it is not a short duration sound.

When using the subjective method, uncertainty may be reduced when allocating **'character corrections'** by undertaking multiple observations by the same or more than one practitioner.

A written record of observations, considerations and adopted rating penalties should be kept to support conclusions and for inclusion in the uncertainty assessment.

The supporting commentary to Subclause 9.2 advises 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.'

And

'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'

It should be noted that the practitioner is not restricted to applying tone penalties in 2 dB steps as could be inferred from the supporting text to Subclause 9.2 and may apply a **'character correction'** anywhere between 0 and 6 dB. Similarly, for impulses, the practitioner may apply a penalty between 0 and 9 dB rather than being restricted to 3 dB steps.

There is scope for various interpretations of **'intermittency'**, and the word is not defined in BS 4142. Its presence should be considered in the context of the reference time interval and in conjunction with any **'on-time'** correction. If a source is considered to be on for 100% of the reference time interval, an intermittency correction should not, therefore, be applied. It was recognised that, in practice, intermittency (and the associated penalty/on-time correction) might occur in some periods and not in others and how this dynamic was handled should be set out in the body of the report and in the uncertainty assessment. A range of assessment results might be justified. Where an intermittency penalty is considered appropriate, this can be applied in addition to any other penalties.

BS 4142 notes that intermittency requires identifiable on/off conditions; a process that is impulsive but operates continuously during the reference period would not normally be considered intermittent

14 ANSI/ASA S1.1-2013, published by the American National Standards Institute

An example might include a dual level alarm that has distinct on/off conditions that are part of its operational cycle. This might be considered impulsive if the onset time met the required conditions, and possibly tonal too. However, if it operates throughout the assessment period, it would not be considered intermittent.

The question of additive **rating penalties** was considered at length, specifically interpretation of Note 2 to Subclause 9.2 of BS 4142. The WG thought it was clear that **rating penalties** for tonality and impulsivity could be additive where both characteristics are clearly present, for example, a reversing alarm which is a pulsing tone.

The **rating penalty** for intermittency can be added linearly where a penalty for "tonality", "impulsivity" has already been applied.

The **rating penalty** for "other sound" cannot be applied where a penalty has already been made for tonal, impulsive or intermittent characteristics.

The total **rating penalty** value should be reviewed for reasonableness in the context of the situation. It is unlikely, but not impossible, that a maximum penalty of +18dB would be necessary in the right circumstances (+9 dB for tonality, +6 dB for impulsivity and +3 dB for intermittency).

Objective Methods

One-third octave method

BS 4142 advises that if the subjective method is not sufficient for assessing the audibility of tones, the one-third octave method or reference method should be used as appropriate. The one-third octave method is described in Annex C.

There is little available psychoacoustic model evidence or widely established subjective response data underpinning the one-third octave method.

There are three principal reasons that the one-third octave method could prove misleading when trying to establish the audibility of tones in a sound:

1. Many real-life noises containing tonal components may have many spectral peaks across a range of frequencies resulting in the elevation of several one-third octave bands rather than a single one-third octave band in isolation;
2. Tones with frequencies near the boundary between two adjacent one-third octave bands will raise the level of both one-third octave bands making some tones undetectable; and
3. At frequencies above around 500 Hz the critical band and one-third octave band widths are very similar. For tones near the centre of one-third octave bands, a measured one-third octave band would contain both the energy from the tone and the energy from masking noise in the surrounding critical band. Under these circumstances the one-third octave method could identify a tone when no audible tone was present.

BS 4142 also restricts the practitioner to applying either a 0 dB penalty or a +6 dB penalty, with no valid intermediate values. This is considered too crude by the WG and on this basis the method should be used with caution.

Reference Method

The reference method for the assessment of tonal noise in BS 4142 is the Joint Nordic 2 method, which is based on the critical band model of masking tones by noise. This model has been developed and refined from extensive subjective testing and analysis and is considered to be robust and defensible given the current knowledge base.

The WG recognised that the reference method for tonality (the Joint Nordic Method) set out in Annex D was more onerous to apply than the objective method but felt that it was more robust; supported by a greater weight of evidence; and provided a more precise result. The cost of the instrumentation and software necessary for its application is no longer prohibitive for professional acousticians. It was noted that Annex D is a less detailed and comprehensive description of the method than in ISO 1996-2, which is likely to be easier to follow

if applying manually.

The WG had some concerns about the method for measuring the prominence of impulsive sounds set out in Annex E, although did not have a consensus view. It was recognised that application of the objective method could flag some intermittent sources as impulsive (by virtue of the stop/start change). Some felt that application of both rating penalties in these circumstances was double counting whilst others felt that applying both penalties additively may sometimes be appropriate.

New Sources

Where a new sound source is to be introduced, acoustic characteristics may not be immediately apparent or identifiable, even upon consideration of the sound emission data. It may be necessary to measure or observe similar existing sound sources to determine the likely character corrections. When using these observations care should be taken to account for the likely character of the sound at the assessment location which may differ from the observed situation. The potential for the background sound to mask the sound character should also be carefully considered.

Careful attention should be given to minimise uncertainty when applying penalties for future sources as discussed further in the next section. The context is also an important factor, particularly where old plant is being replaced.

10. Uncertainty

10.1 General

The consideration of uncertainty is a fluid process which ought to factor into every stage of the assessment and should be revised with any new information. The consideration of uncertainty should not be left until the assessment is complete; it should be considered from the outset. The early consideration of uncertainties can help to inform the preparation and delivery of the assessment method and ultimately minimise their extent.

The extent to which uncertainty is considered should be proportionate to the scale and nature of the assessment. For simple assessments, or those with very clear conclusions, a brief qualitative discussion of the main sources of uncertainty and their potential (or lack thereof) to influence the conclusions of the assessment may be sufficient. For example, see Table A.9 **Example 9: Assessment**.

For more complex assessments or situations where the outcome might be marginal with respect to the likelihood of adverse impacts, a more detailed and comprehensive consideration is likely to be necessary. This may include, in part, an uncertainty budget calculation based on numerical values taken from an appropriate standard, a reliable source, or derived from site measurements; and a qualitative statement of the other factors potentially affecting the assessment.

In situations that might be described as marginal, the level of uncertainty is likely to be more important than situations that are clear. This is particularly true where the uncertainty might affect the assessment outcome. For example, uncertainty of ±2dB may be of little significance in a situation where the rating level is 15dB below the background sound level, but highly significant where the rating level is 2dB above the background sound level.

There are two principle types of uncertainty, 'quantifiable' and 'unquantifiable'. Both types of uncertainty should be taken into account.

Quantifiable sources of uncertainty are those for which a numerical value can be reliably determined at the time of assessment, including:

- Instrumentation uncertainty;
- Quoted uncertainty in sound power level data from plant manufacturers;
- Measurement uncertainty (distance, directionality, etc);
- Meteorological conditions as discussed further below;
- Calculation uncertainty.

Combining these values to give a total numerical value for the quantified uncertainty is not always straightforward and the values should not normally be added together. A simple method for combining uncertainties that could be used is the root sum of the squares, as set out in Section 3.1 of the Salford University Guide[15], however, it is important to understand and be able to justify applying this result.

Unquantifiable uncertainty comprises factors which do not at that time directly affect the numerical values of an assessment but may otherwise affect the confidence in the conclusions. These may include;

- Seasonal variations in sound levels;
- Operational uncertainties such as workload;
- Non-typical working conditions during measurements;
- Varying site or local conditions;
- Third party changes;
- Sampling error or bias;
- Unconscious assessor bias.

15 A Good Practice Guide on the Sources and Magnitude of Uncertainty Arising in the Practical Measurement of Environmental Noise, N J Craven & G Kerry, 2007, University of Salford.

It is re-iterated that in most cases, not all of the quantifiable and unquantifiable factors listed above would be taken into account. The assessment should be proportionate to the task in hand.

BS 4142 assessments rely on comparisons between specific and background sound levels; two inherently variable quantities, both spatially and temporally. One of the key uncertainties within any assessment relates to the selection, determination and evaluation of suitably representative specific and background sound levels. While single values are convenient and may provide what at first appear to be clear conclusions, multiple values, or ranges of values, may often be more appropriate to quantify the full range of potential impacts, and potentially reduce uncertainty. This is especially applicable to values derived from modelling, where single value outputs are common for a given assessment location.

Appendix B of BS 4142 contains useful information and guidance on the consideration of uncertainty and good practice for reducing uncertainty. Additional guidance on sources of uncertainty and relevant good practice can be found in the aforementioned Salford University Good Practice Guide and the UKAS guide M3003[16].

10.2 Uncertainty of measured values

The WG felt that the discussions of individual elements of uncertainty were applicable to both measured values and calculations and so are presented together below.

10.3 Uncertainty in calculations

Instrumentation

Narang and Bell[17] have reported that the accuracy expected by using a Class 1 instrument (ignoring environmental effects) will depend on factors such as the spectrum of sound, the nature of the sound field and the measurement parameter of interest. The uncertainties can be estimated by examining standard uncertainties using allowable tolerances minus the maximum allowable test laboratory uncertainties given in IEC 61672-1, e.g.:

Table 1 Standard uncertainties using allowable tolerances minus test laboratory tolerances given in IEC 61672-1 (source: Narang and Bell, Table 14)

SLM Class	Frequency weighting dB	Directional response dB	Level linearity dB	Toneburst response dB	Calibrator (IEC 61672) dB	Supply voltage dB	Combined standard uncertainty dB
Class 1	0.5	0.5	0.4	0.25	0.125	0.05	0.9

16 United Kingdom Accreditation Service M3003 edition 3 November 2012 The Expression of Uncertainty and Confidence in Measurement

17 Inter Noise 2008 "New IEC Standards and Periodic Testing of Sound Level Meters"

The paper also noted that the standard uncertainty for carrying out practical A-weighted sound pressure level (Lp) measurements with a Class 1 SLM, using statistical analysis of measured data on 22 different SLMs from 9 manufacturers, was estimated to be ± 0.4 dB. The main contributions were from time-weighting, RMS detector and linearity. The level linearity uncertainty can be minimised by choosing the same indicator range as that used when the sound calibrator was applied, or by using an instrument with a single large dynamic range.

When measuring low sound pressure levels, the uncertainties due to self-generated noise or residual noise (sound left after removal of specific sound under consideration) should not be ignored and will depend on measurement parameter, the measured difference between total and residual sound levels, and their uncertainties.

When measuring in low noise environments or in strong electrical fields, consideration must, therefore, be given to the instrument's noise floor. This can be measured in accordance with Subclause 10.2 of IEC 61672-3, where the microphone is replaced by an electrical input signal device (e.g. a dummy microphone), thus self-generated noise is measured with the exclusion of any acoustic input via the microphone. No tolerances are given for this test in the IEC and it is intended only to measure and report the values. The noise floor will therefore vary between instruments. Ideally, the measured background sound level should be at least 10 dB above the noise floor of the instrumentation chain.

A potential source of uncertainty when undertaking attended sound measurements is reflections due to the presence of the observer and care should be taken.

Modelling

The use of commercial sound modelling software has the potential to introduce unquantified and unappreciated error. Experience amongst the WG indicated that it is not always clear how modelling packages apply standards or make predictions, particularly where elements of the model lie outside the prescriptive methods set out in standards. Commercial modelling packages such as CadnaA® or SoundPLAN® are intended to replicate the calculation process of standard methods such as ISO 9613-2[18], BS5228-1:2009+A1:2014[19], CRTN[20], CRN[21], or their equivalents. It is important, therefore, to understand the emulated method sufficiently to be able to interrogate the predictions made by the software. Good modelling practice should be used to reduce potential errors and these should be described in a qualitative manner in the report. It is also good practice to record, check for suitability, and to report the model's configuration, settings, and the calculation methods which are applied. As with all consideration of uncertainty, setting up the model to reduce uncertainties should be considered at the early stages of modelling.

For small and simple models it should be possible to carry out parallel assessments using manual calculation methods. This dual technique can provide comfort that the model is performing well prior to progressing to more complex models. When generating larger models, it is also good practice to have calculated sound level flags at points of known sound level to give validation check values that can be compared to, for example, manufacturers' sound pressure level data or measurement data.

In particular, the modeller should understand how the software deals with reflections, screening losses due to intervening barriers and rounding, as these are common deviations from standard methodologies and settings may need to be adjusted to give the most appropriate configuration.

It is important to consider the uncertainty of any inputs into the model, such as topography, building and barrier specifications, source levels, and ground types. The outputs of any acoustic model will only ever be as reliable as the inputs. Where multiple time periods or operating conditions are being assessed, these should be considered within the setup of the model and modelled separately if necessary.

It is important to be aware that a model tends to provide a single scenario output, and that this is representative of only the specified configuration of the model (for example wind direction) and for the specified source levels. This may not represent the range of values experienced in reality.

18 ISO 9613-2:1996(en) Acoustics — Attenuation of sound during propagation outdoors — Part 2: General method of calculation

19 Code of practice for noise and vibration control on construction and open sites. Noise

20 Calculation of Road Traffic Noise 1988 – Department of Transport, Welsh Office

21 Calculation of railway noise – 1995 – Department of Transport, ISBN 0115517545

For example; consider an industrial facility with a specific sound level that has been modelled as 55 dB at the assessment location, based on typical operating conditions and downwind propagation conditions. The specific sound level experienced at the assessment location may vary in reality by ±5 dB due to variations in the operating conditions. In upwind propagation conditions, the specific sound level may be predicted to be 10 dB lower at the assessment location, resulting in a value of 45 dB (±5 dB depending on operating conditions).

Considering a background sound level at consistently 50 dB in all conditions at the assessment location and assuming no character corrections, the conclusions could be affected by which weather conditions were more prevalent. If upwind conditions unfavourable to sound propagation are the prevailing weather conditions, this would mean that the specific sound level would normally vary from 40 dB to 50 dB, and only in some conditions would the specific sound level reach 55 dB to 60 dB. This would mean that the "usual" difference between rating level and background sound level would range from -10 dB to 0 dB, but in some circumstances could reach +5 dB to +10 dB, resulting in a range of possible outcomes. This range of outcomes would be even more complex if the background sound also varied significantly, which may also coincide with the wind direction.

In this situation, it would be good practice to report and describe the range of potential impacts and outcomes, and give an indication as to the prevalence and likelihood of these. A robust conclusion might state that the impact from the industrial facility at the assessment location is likely to be low, but there remains a risk that in some conditions an adverse impact of sound from the facility could occur, although a significant adverse impact is unlikely.

Calculation

The following table represents the uncertainty inherent in a logarithmic subtraction calculation where there is an uncertainty of ±0.5 dB in the input data. Potential calculation error is reported to one decimal place.

Table 2 Uncertainty in logarithmic subtraction calculations

Difference between Ambient and Residual Sound Levels	Upper error when logarithmically subtracting	Lower error when logarithmically subtracting
+1 dB (e.g. 50 dB and 49 dB)	+3.0 dB (50.5 dB - - 48.5 dB)	N/A (49.5 dB - - 49.5 dB)
+2 dB (e.g. 50 dB and 48 dB)	+1.8 dB (50.5 dB - - 47.5 dB)	-3.0 dB (49.5 dB - - 48.5 dB)
+3 dB (e.g. 50 dB and 47 dB)	+1.3 dB (50.5 dB - - 46.5 dB)	-1.8 dB (49.5 dB - - 47.5 dB)
+4 dB (e.g. 50 dB and 46 dB)	+1.1 dB (50.5 dB - - 45.5 dB)	-1.3 dB (49.5 dB - - 46.5 dB)
+5 dB (e.g. 50 dB and 45 dB)	+0.9 dB (50.5 dB - - 44.5 dB)	-1.1 dB (49.5 dB - - 45.5 dB)
+6 dB (e.g. 50 dB and 44 dB)	+0.8 dB (50.5 dB - - 43.5 dB)	-0.9 dB (49.5 dB - - 44.5 dB)
+7 dB (e.g. 50 dB and 43 dB)	+0.7 dB (50.5 dB - - 42.5 dB)	-0.8 dB (49.5 dB - - 43.5 dB)
+8 dB (e.g. 50 dB and 42 dB)	+0.7 dB (50.5 dB - - 41.5 dB)	-0.7 dB (49.5 dB - - 42.5 dB)
+9 dB (e.g. 50 dB and 41 dB)	+0.6 dB (50.5 dB - - 40.5 dB)	-0.7 dB (49.5 dB - - 41.5 dB)
+10 dB (e.g. 50 dB and 40 dB)	+0.6 dB (50.5 dB - - 39.5 dB)	-0.6 dB (49.5 dB - - 40.5 dB)

As can be seen from the above table, a difference of at least +3 dB would be required for the upper and lower error to be 3.0 dB or lower. A difference of more than +5 dB is needed for both the upper and lower error to be below 1.0 dB. It should be noted that this assumes an uncertainty of ±0.5 dB in the input data; a larger uncertainty will result in a larger potential error in the calculation.

Propagation and Meteorological Conditions

One key uncertainty consideration is that of sound propagation which can include geometric, topographic and meteorological factors. Under varying conditions, such as differing wind direction or ground hardness, sound can propagate very differently and result in substantially higher or lower sound levels. Set out below are a series of points on propagation that should be taken into account to reduce uncertainty.

Geometry

The size and shape of the sound source under consideration will affect how sound is propagated; one useful reference is the Rathe JSV paper[22] but other guidance is available. The assessor should consider whether the source will act as a point, line or area source and over what distances. Directional characteristics should also be taken into account.

Topography

Topography is the arrangement of natural and artificial features including ground levels and types, buildings, barriers/reflectors and other screening objects. Broadly speaking barriers/reflectors will have greater significance when closer to the source or receiver, and ground/air absorption will become more significant as the distance between source and receiver increases. Practitioners should be aware that spectral content of sound will change due to screening objects and absorption over distance.

Weather Conditions

It is important to consider how weather conditions may vary and how this may affect both propagation from the source under consideration and background sound sources.

Wind direction is likely to be amongst the most important of these considerations as it often varies significantly and can affect both specific and background sound levels, potentially resulting in a range of outcomes. Where the wind direction is likely to be critical, directional filtering of background datasets and the effect of wind direction on source propagation should be considered.

Other meteorological considerations which could influence sound levels include the following (whether these are all considered should depend on the scale of the assessment, or the magnitude of the effect):

- Wind speed gradient – where the wind speed gradient is greater (i.e. the wind speed increases rapidly with altitude) refraction effects due to the sound propagating in relation to wind direction will be more pronounced, and vice versa.
- Temperature inversion – air temperature normally decreases with altitude, resulting in a slower sound speed at higher altitudes and an upward refraction effect, which reduces the amount of sound propagating over distance. In some conditions however, a temperature inversion can occur, whereby the temperature initially increases with altitude before decreasing. This results in a band or channel of increased temperature air (and thus increased sound speeds) which cause an initial downward refraction effect, allowing sound to propagate much farther than it otherwise would. The average height of sound propagation may be high above the ground, and thus in some cases can be found to propagate "over the top" of a location, resulting in higher sound levels at far distances than at medium distances.

Temperature inversions can also influence the wind direction at higher altitudes independently of the wind direction at ground level, resulting in complex propagation effects.

22 E.J. Rathe - Note on two common problems of sound propagation, Journal of Sound and Vibration 10(3):pp472-479 November 1969

Signs of a temperature inversion include:

- Changes in sunlight over a relatively short period of time, such as sunrise, sunset, or rapid changes in cloud cover;
- Movement of warm bodies of air over water;
- Clouds at different altitudes moving in different directions; and
- Sound sources at large distances appearing notably louder than expected.

- Humidity – the relative humidity of the air can result in different absorption of sound over distance. Higher humidity air generally absorbs more high frequency sound, and as such reduces overall levels, as well as altering the spectral content.
- Direct effects – ambient sound levels can be influenced by adverse weather conditions directly, including sound generated by wind on the microphone/windshield, or the sound of rainfall landing on objects and the ground.
- Effects on sound sources – wet roads generally result in more sound than dry roads, whereas wet rails generally result in less sound than dry rails. Different driving styles are also likely to occur in wet, snowy or icy conditions. Other sources' sound emissions may also be influenced by different weather conditions.

Many aspects of these considerations may not be quantified, but in some cases a qualitative consideration of the extent to which these factors may affect conclusions could be appropriate.

Interference patterns

Where there are strong tonal components of sound, particularly at low frequency, interference patterns can occur resulting in spatial variation of sound levels, which may add to uncertainty.

Common examples include electrical equipment such as transformers and substations; which often emit tones of 50 Hz, 100 Hz and other harmonics of these frequencies; or large diesel engines, which can have low frequency rotational speeds that generate low frequency tones.

Reporting Uncertainty

When reporting the uncertainty, it is often sufficient to list all known factors affecting the overall uncertainty of the assessment, as well as the extent and type of effect likely to occur (if known), and then to state whether the overall uncertainty in the assessment is considered to be small enough that it would not affect the conclusions, materially alters the conclusions one way or another, or introduces risk that the impact experienced at the assessment location would be higher (or lower) than suggested by the prior conclusions.

11. Assessment of Impacts

The commentary at the start of Clause 11 makes two important points:

- The significance of an industrial sound depends on the margin by which it exceeds the background sound level; and
- The context in which the sound occurs is important.

These two principles set the tone for Clause 11, and the clause considers these two points in its two halves.

The first part of Clause 11 looks at what the difference between the rating level and background sound level means in terms of potential impacts.

The four assessment outcomes, listed as (a) to (d) are self-explanatory.

However, it is worth noting that BS 4142 emphasises that the levels given are not hard boundaries and are quoted as being 'around' the value quoted.

It is also important to note that the numerical outcome only represents the initial estimate of impact, as stated in the first paragraph of Clause 11 (the first paragraph after the commentary), and that contextual matters should be considered before determining what the potential impact is.

To undertake the numerical analysis, it is necessary to understand what sources comprise the background sound, residual sound, and ambient sound. This speaks to the fundamental principles of BS 4142, insofar as it covers three specific conditions, as described in Subclause 1.2:

1. investigating complaints;
2. assessing sound from existing, proposed, new or modified industrial sound sources; or
3. assessing sound at proposed new dwellings.

If the situation does not fall into one of these categories, for example, if the potential impact of a historic industrial source is to be considered to inform a contextual argument, then care should be taken when applying BS 4142. The WG does not take the view that BS 4142 should never be applied in situations outside the three given in Subclause 1.2, but where it is used outside of these situations, justification should be given as to why BS 4142 is being used, what the limitations of its use might be, and what special precautions should be made in the application of any assessment outcomes.

Specific and Background Sound Levels

For scenarios (1) and (2), it should be reasonably straight-forward to ascribe the various sound sources to the appropriate BS 4142: 2014 description, i.e.:

1. the sound source being complained about is the specific sound source, everything else is the background/residual;
2. the proposed, new or modified industrial source is the specific sound source, and everything else is the background/residual.

There may be subtleties as to how these terms are applied in practice. For example, if a complaint is about "general factory noise", there may be reasonable justifications for either assessing the entirety of an industrial facility as the specific sound source, or identifying discrete elements of the overall facility to assess in isolation from the remainder of the facility. In both instances, it is expected that justification should be provided to defend the approach.

For new dwellings (Scenario 3) the situation is less clear and there was much discussion in the WG as to what constitutes a valid approach under BS 4142.

The fourth paragraph of the notes to Subclause 8.1 states that ***'existing industrial or commercial sources can be included in the background sound level; as long as they are separate to the specific sound.'***

BS 4142 is clear that the residual and background sound sources/levels should not include any contribution from the specific sound source. Given this requirement, background sound measurements may involve measuring during periods where the specific sound source is switched off, or using a comparable alternative measurement location (as allowed under Subclause 8.1.2). When selecting an alternative location it should be subject to reasonably comparable residual sound contributions as the assessment location.

However, the note to Subclause 8.5 states ***'Where a new noise-sensitive receptor is introduced and there is extant industrial and/or commercial sound, it ought to be recognized that the industrial and/or commercial sound forms a component of the acoustic environment. In such circumstances other guidance and criteria in addition to or alternative to this standard can also inform the appropriateness of both introducing a new noise-sensitive receptor and the extent of required noise mitigation.'***

The WG recognise the risk that underestimating the contribution of legitimate commercial residual sources to the background sound level could potentially lead to unrepresentatively adverse outcomes.

The WG recognises that a numerical assessment fully in accordance with BS 4142 may not be possible in some circumstances and alternative guidance and standards should be referenced, although care should be taken not to apply them beyond their own stated scope or limitations.

Examples might include the application of BS8233: 2014 where an industrial/commercial sound source is without a specific character and new residential development is proposed nearby. This analysis may inform the contextual elements of a BS 4142 assessment.

Where existing industrial/commercial sound sources are being assessed (e.g. new residential development is proposed nearby), different approaches might be adopted depending on whether the industrial/commercial source is continuous or intermittent, whether there are ancillary sources present, or where one particular industrial/commercial premises dominates.

Multiple Assessment Outcomes

More than one assessment may be appropriate, as BS 4142 states. Examples of why more than one assessment might be appropriate include:

- variation in **background sound** levels;
- variation in **specific sound** levels, for example, different plant or activities at different times; or
- variation in **rating penalties** as a result of variations in prominence of acoustic features.

In such circumstances, a range of assessment outcomes might result. The assessor should set out the circumstances in which each outcome is valid and any other factors that are relevant.

An example might be a factory that operates at two distinct levels at different times of the day. In that case, two assessment outcomes would result, and the assessor should make clear the circumstances in which the two outcomes are valid, e.g. outcome 1 during the daytime, outcome 2 at night, or outcome 1 in periods of peak activity in say November and December, and outcome 2 at all other times.

Context

The second part of Clause 11 sets out some of the contextual matters that should be taken into account once the initial numerical estimate has been determined.

Three contextual elements are set out in Clause 11, but it is important to note that the list is not exhaustive and all pertinent factors should be considered.

The three types of context set out in Clause 11 are:

1. aspects of the absolute level;
2. aspects of character; and
3. aspects of the receptor, including physical measures designed to reduce noise.

Some comments on each of the three contextual matters raised in Clause 11 are set out here.

Subclause 11(1)

The standard states that the absolute level of sound can be of significance, where the residual values are low and where they are high, and should be taken into account when determining the overall impact of a particular specific sound source.

The second paragraph notes that absolute levels may be as, or more, important than relative outcomes where background and rating levels are low. It is important to note that both background and rating levels would need to be low for this particular caveat to apply.

BS 4142 does not indicate how the initial estimate of impact should be adjusted when background and rating levels are low, only that the absolute levels may be more important than the difference between the two values. It is likely that where the background and rating levels are low, the absolute levels might suggest a more acceptable outcome than would otherwise be suggested by the difference between the values. For example a situation might be considered acceptable where a rating level of 30dB is 10dB above a background sound level of 20dB, i.e. an initial estimate of a significant adverse impact is modified by the low rating and background sound levels.

There may be situations where the opposite is true, and it is for the assessor to justify any modifications to the initial estimate of impact.

BS 4142 does not define 'low' in the context of background sound levels nor rating levels. The note to the Scope of the 1997 version of BS 4142 defined very low background sound levels as being less than about 30 dB L_{A90}, and low rating levels as being less than about 35 dB $L_{Ar,Tr}$.

The WG suggest that similar values would not be unreasonable in the context of BS 4142, but that the assessor should make a judgement and justify it where appropriate.

The third paragraph states that **"where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts"**.

In the ordinary application of BS 4142 the residual sound level is not compared with the background sound level to determine the level of impact. The third paragraph is therefore taken to mean that the level of impact caused by the residual level has been determined by professional judgement or with reference to another document, such as the Noise Insulation Regulations 1975 (as amended 1988). Where professional judgement is used, it should be appropriately justified.

Where the residual sound levels are very high, a significant adverse impact might be declared in a situation where the rating level exceeds the background sound level by, say, 4dB, i.e. since the residual sound levels are already considered to cause a significant impact, any worsening of the situation would be considered a significant adverse impact, even if the difference between the rating level and background sound level would not suggest this to be the case.

Subclause 11(2)

The second aspect of context described in BS 4142 relates to the character and level of the specific sound. In essence, whether or not the character of the sound is distinguishable from the character of the ambient or residual acoustic environment, or is incongruous.

BS 4142 does not provide instruction as to how to treat the assessment outcomes in these circumstances, nor does it explain how to distinguish between this contextual consideration and the process for applying **rating penalties**. The latter is itself informed by the distinctive characteristics of the specific sound in the context of the residual sound environment.

It is the WG's view that where character-based contextual matters are taken into account, the assessor should make it clear how these matters are distinct from those that informed the **rating level** corrections, and what the implications of these further character assessments should be.

For example; new deliveries on an estate entailing rating penalties for reversing alarms and impulsive noise but these types of noise are already present at other existing premises, so contextually the impact is reduced. Conversely, where the residual level is largely comprised of natural sounds, such as the sea or birdsong, so the impact from the specific source might be increased.

Subclause 11(3)

The third contextual matter described in Clause 11 relates to the receptor itself. It is important to note that the reference at the start of this section of BS 4142 to **'the sensitivity of the receptor'** refers to a generic receptor type, i.e. a dwelling, and not to the particular attitudes or responses of a particular person (although if the residential receptor type is specific it may have a bearing e.g. student accommodation).

The WG notes that this part of BS 4142 allows the internal noise environment to be considered, despite BS 4142 excluding such matters from its Scope (Subclauses 1.1, 1.2 and 1.3). The WG considers that the consideration of the internal noise environment is only valid in a BS 4142 assessment where it relates to the contextual elements of the assessment.

It is not necessarily required to refer to other standards or guidance to inform this issue. However, where other standards or guidelines are referenced, e.g. BS8233: 2014 or WHO Guidelines, the assessor should make clear any limitations of those documents and the extent to which they can be relied upon.

Other Contextual Matters

The assessor may also wish to consider matters such as the:

- character of a particular neighbourhood;
- former uses at or close to a site;
- legitimacy of the industrial use, e.g. planning permissions or environmental permits;
- implementation of best practicable means for a given process or activity; or
- local convention or perceptions.

When relying on such matters, it is incumbent on the assessor to make clear all elements of context.

For example; a former industrial use may be less relevant if it ceased 10 years previously, than a use that ceased within the previous six months. Setting out the context in this way is important so that the reader is fully aware of the point being made.

There is no theoretical limit to how the context can or should influence the impact assessment, but any alteration of the conclusions of an assessment due to the context should be sufficiently explained and justified for the specific circumstances in question.

For example; a coffee shop with drive thru facility located adjacent to a fairly busy road with traffic lights and constant stop/start traffic, with residential properties nearby. In these circumstances the noise climate is unlikely to change in any perceptible way due to the addition of vehicles moving and idling in the drive thru area. However, during the evening, the gaps in the general traffic could reduce the background sound level sufficiently that an adverse or significant adverse impact is suggested. An intermittency correction could also be considered appropriate. In this example, the assessor might legitimately take the view that the context is at odds with the initial (numerical) assessment, and substantially adjust the conclusions of the assessment on the basis of the context.

12. Information to be reported

The list set out in Clause 12 provides a useful but not a mandatory list, as is noted by the words "as appropriate" in the first sentence.

In general terms, the items reported in a BS 4142 assessment report should be proportionate to the size/scale/nature of the assessment.

Some points on the items listed in Clause 12 that the WG wished to make:

Subclause 12(a) – assessors should have regard to the distinction between corporate and personal risk, and the policies that individual companies have on this. Individuals need not be named if that is company policy but the experience and competence of all the staff involved should be listed where appropriate.

Subclause 12(d) – the assessment of sensitivity may include:

i. The use of external amenity areas;

ii. The acoustic performance of the building envelope and ventilation;

iii. The internal layout of the building, such as whether occupants may have the use of several rooms or one.

Subclause 12(h) – not all of this information will be required for every assessment. The weather conditions listed should be proportionate to the scale and nature of the assessment.

Annexes

Annex A Examples of how to use the standard to obtain ratings

This annex provides 11 examples of BS 4142 in practice, demonstrating various aspects of how it could be implemented and decisions that could be taken. These examples are discussed in more detail in the next section of this document, Examples.

Annex B Consideration of uncertainty and good practice for reducing uncertainty

This annex provides detailed information regarding uncertainty in an assessment. Many of the considerations included in this section are already mentioned in Section 10 of this document, but Annex B contains a lot of useful additional information, providing direct advice and helpful good practice guidance for considering a wide range of uncertainty factors.

Annex C Objective method for assessing the audibility of tones in sound: One-third octave method

This annex describes the procedure for objectively assessing the audibility of tones by the one-third octave method. It was the view of the WG that while this method is simple and easy to implement, it is overly crude and vulnerable to inaccurate or misleading results, and that it should be used with caution. The application of Annex C in relation to deriving a specific sound level is discussed in Section 9 of this document.

Annex D Objective method for assessing the audibility of tones in sound: Reference method

This annex describes the procedure for objectively assessing the audibility of tones by the reference method. This method follows the Joint Nordic Method 2 found in ISO 1996-2, though it is noted that the link embedded in BS 4142:2014+A1:2019 directs to BS 7445-2. The latest version of BS 7445-2 at the time of writing is equivalent to earlier versions of ISO 1996-2, but does not contain this method. The WG considered that this method was more complex and onerous to apply than the one-third octave method in Annex C but also that it was more robust. It was noted that Annex D is a less detailed and comprehensive description of the method than that found in ISO 1996-2 (and some earlier publications of the method), which are likely to be easier to use and to follow if using a manual approach. Many commercially available software packages are able to automate this method. The application of Annex D in relation to deriving a specific sound level is discussed in Section 9 of this document.

Annex E Objective method for measuring the prominence of impulsive sounds and for adjustment of L_{Aeq}

This annex describes a procedure for objectively assessing the prominence of impulsive sounds. This method is derived from the Nordtest Method NT ACOU 112. While the method is not immediately straightforward to implement if using a manual approach, the instructions are largely clear and able to be followed through in a manual process if needed, which is helpful. Many commercially available software packages are able to automate this method. The application of Annex E in relation to deriving a specific sound level is discussed in Section 9 of this document.

Examples Pre-amble

The examples in BS 4142 present some applications of the methodology to illustrate specific individual elements of the process. For example, 'Hums', 'Sound to be rated does not significantly exceed the background sound', 'Effect of residual sound' and so on. These present idealised situations where each effect is present in isolation, although, in real life several different effects may be apparent in combination.

Firstly, it is worth noting the introductory guidance note:

'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. It is assumed in all these examples that full information as set out in Clause 12 would be included in the report and is not therefore given here.'

The assessments in the examples are presented in tabular form. Whilst alternative formats can be used, such as a report based format with separate sections or discussions as is appropriate to the intended use of the report, the use of a table in the example does imply that the same format could be an acceptable summary presentational style (with the supporting information from Clause 12 as appropriate).

As must always be remembered, it is the character of the sound that can be heard at the assessment location that is relevant for the acoustic feature corrections. It is not relevant if the acoustic feature is discernible only close to the source and not at the assessment location.

It is also important to remember that the assessment is concerned with the potential effects on people and so the assessment locations should reflect the actual usage of the residence or associated amenity area. This may mean that assessment locations are within the main amenity area but not necessarily at the boundary.

For example; an assessment location in the part of a garden in normal use might be preferred to one at the most distant boundary of the garden even if the more remote location is closer to the specific source.

It is also worth noting the commentary given for the uncertainty assessment in each example is frequently brief and often relies on the magnitude of the difference between **Rating Level** and **Background Sound**, sometimes discounting the effect of uncertainty if the difference is greater than 7 dB.

This implies that:

i. The uncertainty assessment does not have to be numerical; and

ii. Where the excess of rating level over background is large (or the rating level is significantly below background) then it may be sufficient to state that **'the uncertainty of the measurement does not have any significance to the outcome of the assessment'** (see examples 1, 4, 5 and 9) without further details of the assessment used to reach this conclusion.

Whilst some of the examples suggest that 'large' in this context is ≥7dB (and one suggests the opposite), the assessor should consider the potential uncertainty in their own assessment and decide whether it is material to the outcome (see section 10 of this document for further discussion on this point).

In particular, the application of acoustic feature corrections can generate large differences, so the potential uncertainty in deriving these penalties should also be taken into account.

Annex A (informative) Examples of how to use the standard to obtain ratings

A.1 Example 1: Hums: General acoustic feature correction

This is a relatively straightforward example, however, it does draw out some interesting points and expectations regarding the extent of information required in the report.

Firstly, as with all the examples, refer to the pre-amble to this section.

The example is a new factory that only operates during the day that emits a constant hum which is not attributable to any single source but can be heard at the measurement (assessment) location.

As must always be remembered, it is the fact that the factory hum can be heard at the assessment location that is relevant for the acoustic feature corrections. If the assessment location were more distant or screened such that the hum was not discernible then the acoustic feature correction would be different; it is not relevant that the hum would be discernible close to the source.

The example assumes that the sound before the factory is operational and after is relatively steady and continuous. This assumption could be based on discussions with the factory owner, EHO or local residents and appears to have been used to plan the measurement survey, which has been carried out over only a one hour period.

The example is, therefore, demonstrating the benefit of a prior assessment of the context and operation of the site, allowing a shortened attended measurement in this instance.

The example also states that it is reasonable to assume the background is unchanged after the factory is turned on, this is a fundamental assumption of the BS 4142 method and the possibility of background being in some way dependent on the source operating should be considered, e.g. traffic on surrounding roads.

In measuring the relevant sound levels, the example notes that **'A longer measurement period up to 1h could have been used'**, implying that the measurement duration should not exceed the reference time interval.

The Example 1 assessment is then presented in tabular form. Whilst alternative formats can be used, such as a report based format with separate sections or discussions as is appropriate to the intended use of the report, the use of a table in the example does imply that the same format is an acceptable presentational style.

It is worth drawing out the point about the acoustic feature correction used. The correction for **'Other sound characteristics'** has been used on the basis that the source is not tonal, intermittent or impulsive at the assessment location but it is distinctive against the residual acoustic environment. If the same source was being assessed at a more distant or screened location where the hum was not distinctive against the residual acoustic environment then the acoustic feature correction would not apply.

The acoustic feature must be evident at the assessment location and not necessarily close to the source.

It is also worth noting the commentary given for the uncertainty assessment **'The excess of the rating level over the background sound level is very large and in this instance the uncertainty of the measurement does not have any significance to the outcome of the assessment'**.

Where **Rating Level** is closer in value to the **Background Sound** level, a more detailed assessment of uncertainty should be undertaken.

The example also does not include a discussion of context. We presume the author felt there were no mitigating circumstances that should be taken into account, however, a short statement to that effect would have been useful.

A.2 Example 2: Sound to be rated does not significantly exceed the background sound

This example is similar to example 1, but where the residual sound level is higher and so a correction needs to be made to the ambient sound level to derive the specific sound level.

Here there is a relatively small difference of 5dB between the ambient sound level and the residual sound level, so clearly the residual sound is influencing the ambient sound. The example suggests three potential approaches which can be considered to be suitable in terms of a BS 4142 assessment to obtain a better reading of the **specific sound level**:

1. Apply a correction to account for the residual sound – this is the option chosen in the example.
2. Return at a time when the residual noise is lower – perhaps this would be ideal but there is no guarantee it would be low enough for a correction not still to be needed and there may be practical restrictions to such an approach.
3. Move closer to the source – care needs to be taken to ensure that differences in position are accounted for, i.e. not just distance but differences in screening, reflections, and other propagation issues.

The example uses the first option **'because the sound levels are fairly steady and do not vary much over time'**. It may still have been appropriate to take this option if either ambient or residual sound levels had been less steady, but longer measurement periods may have been needed to allow for variations. There needs to be confidence that the residual component of the sound was reasonably consistent for both measurements.

The wording of the example suggests that the specific sound source was a particular item on an industrial site. **"Figure A.2 shows a short extract of the typical time variation of the level before and after the specific sound source was turned on."** However, in the table, the background sound level appears to have been taken during a shutdown – presumably an entire factory shutdown, rather than a shutdown of the specific source. In this example, therefore, the assessor presumably considered that the specific sound was most appropriately assessed against the background sound without the rest of the factory. Whether or not to include noise from the general operation of the factory as part of the residual sound climate i.e. separate from the specific source, should be considered on a case by case basis with appropriate justification provided (see Section 8 of the main document for further discussion on this issue). For instance, if this investigation was the first part of an overall complaint about the factory noise then a shutdown comparison may be appropriate. However, if the factory is long established and has no distinctive features then it may be more appropriate to use the 'specific source-off' condition for the background sound level.

The example does not include a discussion of context which would be particularly important in this case as the assessor used **'professional judgement'** to give a slightly different interpretation to the basic quantitative assessment.

It is worth noting the commentary given for the uncertainty assessment, **'The measurements were taken under repeatable conditions and the uncertainty in the result will be low'**

This implies that the assessor considers that repeatability is in itself an adequate determining factor for low uncertainty whereas this has not been demonstrated. Repeatability is essentially a clear description of the conditions so that they can be set up similarly for other tests but repeatability in itself does not necessarily imply low uncertainty. Perhaps the use of "repeatable" was inappropriate and "representative" or "typical" might have been better.

The use of the word **'will'** seems to imply excessive confidence and more discussion would be preferable.

A.3 Example 3: Effect of residual sound

A factory wishes to operate an item of machinery at night, that currently operates during the day. A BS 4142 assessment is undertaken to establish whether there will be an impact.

The example does not state whether other machinery in use by the factory currently operates at night. While it is considered acceptable to include sound from other machinery in the measurement of the background and residual sound levels, as they would be extant industrial/commercial sources that are separate from the specific sound source, the presence of such machinery should be noted in the assessment.

If the operation of this other machinery is intermittent at night, or might otherwise not occur at night for other reasons, an assessment should be carried out for that situation as well. Comment should be made on the likelihood of the various situations occurring.

The example states that the machine emits discernible but not prominent bangs, which is expressed in the present tense. It is not clear whether these characteristics have been determined on the basis of its current operations during the daytime, or whether these characteristics have been considered as "discernible but not prominent" for the night-time period. For the character correction set out in Table A.3 to be correct, it is presumed that the assessment of character correction was determined appropriately for the night-time period.

An assessment of character during one period, for example the daytime, will not necessarily be valid for a different period, for example the night-time; the assessment of the appropriate character correction should be made for the period of interest.

It is noted that a time period of 60 minutes was used for the background sound level measurement. This is considered a reasonable approach given the presence of intermittent car movements at that time, where a shorter measurement period may be overly influenced by a number of car movements during a short period.

It is noted under "Uncertainty of the assessment" that the excess of the rating level over the background sound level is not large, and that the uncertainty of the measurements may influence the outcome. In such circumstances, it would be prudent to measure the background sound level measurements over several representative periods to increase the confidence in the representative background sound level, and to judge the prominence of the acoustic character under a range of conditions.

It's interesting that this example states that the excess of rating level over background is not large and that uncertainty may affect the outcome. However, example 4 has the same difference and example 2 a smaller difference but the same comment is not made in the uncertainty assessment.

Although the example notes that uncertainty might have some influence on the outcome, no commentary is given on what should be done as a consequence. For example, the derivation of rating corrections could be reviewed and reference methods used.

While the specific sound level appears to be more certain, it would be prudent to undertake some repeat measurements to confirm the data used in the assessment is valid. This would be particularly important in situations where small variations in the residual sound level could result in variations in the specific sound level, where in reality, the specific sound source does not vary.

A.4 Example 4: Source is intermittent and cyclic

This example assesses the sound from a factory on the edge of an industrial estate where a new source is proposed.

The factory where the source is located operates 24 hours a day, but the new source will operate cyclically for two consecutive periods in each hour, of 7 min 45 s and 4 min respectively, both of which would take place within a single fifteen minute period for the purposes of a night time assessment. The new process will operate between 06:00 and 02:00.

Figure A.4 shows the specific sound cycling over a twenty minute period, although this is erroneously referenced as one hour in the first paragraph of the example.

The commentary states that the sound characteristics of the new source were assessed by switching the plant on and off at a comparable factory, which already operates the new process and, on this basis, no feature corrections for tonality, impulsivity or other sound characteristics were considered to be applicable at the assessment location.

Intermittency is not mentioned in the commentary or in the assessment table but the absence of any feature correction penalty implies that the assessor did not consider the source to be intermittent. However, Figure A.4 appears to show a source with clearly identifiable on/off conditions at the assessment location (adopted at the comparable factory). It may be that the residual sound level at the actual assessment location is still lower, which may make the intermittency even more readily apparent.

One assumes that the assessor was satisfied that the assessment location adopted at the comparable factory was representative of pertinent factors such as the installation but also that other factors such as the installation, containment and operation of the process; the directivity of the source; and the screening, reflections and absorption on the propagation pathway were also directly comparable. Otherwise, any of these factors could result in an incorrectly assumed specific sound level for the proposed source.

It is considered surprising that no intermittency correction was added, given that the actual sound is some 8dB above the background and the cycle includes both on and off events within a single reference time interval to the extent that an on-time correction is used.

The background sound level for the daytime period was measured at the assessment location *'under comparable weather conditions to those that prevailed when the ambient and residual sound were measured at the other factory'*.

It is unclear as to why this particular point about the weather conditions has been made. It is important that the established background sound level is representative of typical conditions or, potentially, presented as a range where those conditions are known to vary (as a result of the weather conditions or a variety of established operations at the industrial estate for example). As such, extended measurements made under a range of weather and operational conditions would enable a more detailed analysis of background sound levels and the presentation of a range of values if appropriate (see Subclause 8.1.4).

The background sound level for the night time was measured *'during the night-time after 02:00 and a statistical analysis was done to determine the typical background sound level'*. Further information regarding the statistical analysis would have been useful in the example.

It is unclear as to why background sound measurements commenced after 02:00 (see Table A.4) when the source will only operate until 02:00. The wording suggests that the background measurement was for an extended duration after 02:00 (sufficient to yield enough data for a statistical analysis) and so presumably covered multiple nights. It is suggested that the appropriate period for the night time background sound level to be measured would actually have been 23:00 – 02:00 and 06:00 – 07:00 i.e. the actual night time hours when the source will be operating (see Subclause 8.2 and 8.1.4).

A.5 Example 5: Sound being investigated louder than residual and background sound level, which cannot be measured at the assessment location

Although a relatively straightforward example, it is based on a more or less perfect alternative location being available (and no significant uncertainty as a result) and perhaps does not offer assistance for a real world scenario where a perfect alternative location cannot be found.

The example is a long-established industrial installation (presumably operating without complaint) but, following upgrading of plant, is now the subject of complaints. The plant giving rise to complaints operates continuously throughout the night-time and produces steady, mild to prominent tonal components. Note that the example makes a distinction between the **"industrial installation"** and **"the plant giving rise to complaints"**. In other words, it is rating the impact of the new plant, not the entire factory.

Key to the example is the choice and justification of the alternative location, necessitated by the sound under investigation being continuous. A list of nine justifications is given, and comments are given below where necessary.

a) The alternative location is the same distance from residual sound sources (as the assessment position). This is clear enough, although it should be noted that the residual sources should be identified where possible. However, care should be taken not to misread the second half of the sentence – it is not suggesting that the alternative location should also be a similar distance from the source(s) under investigation. **"Sound from the plant is acoustically screened by a significant building structure"** would have been more clear as a separate point. Assuming the rest of the long-established factory was part of the residual sound, the building providing the screening should only screen the new plant. If such an ideal scenario could not be found, then it would require further discussion.

d) This point describes the measurement times and the very small variation in L_{A90} levels at the choice of alternative location. Remembering that the list is the justification for the alternative location, it would seem to be implying that small variation is an indicator of the alternative location being suitable. It was the view of the WG that this was not the intention here and the sub-clause is unclear, being open to different interpretations.

   The description of the measurement times in point d) is also unclear. If the times are a 24 hour clock then the 11:00 to 00:15 would appear to cover a period of 13 hours and 15 minutes, in which case a variation in L_{A90} of just 1 dB would be very unusual, unless residual sound is dominated by the long-established factory and is very steady. If it is 23:00 to 00:15 then it would appear to cover a period of 1 hour and 15 minutes, which is obviously short and would need to be justified.

   i) The absence of transient or other influencing noise events is clearly desirable in that it makes processing very convenient. While this is worth noting, alternative locations with such events are not necessarily unsuitable.

The alternative location would appear to be ideal and justified in clear terms. However, such a location may not be easy to find without significant planning, if at all, and allowances may need to be made and dealt with under the section on uncertainty.

The commentary for the first entry in table A.5 for measured ambient sound level is potentially confusing. Presumably it is meant to say that it was completely dominant and no residual noise was perceptible and/or that there was no transient contamination.

Whether or not to include noise from the general operation of the factory as part of the residual sound climate i.e. separate from the specific source, should be considered on a case by case basis with appropriate justification provided (see Section 8 of the main document for further discussion on this issue).

The correction for tonality has been used on the basis that the source is tonal, not intermittent or impulsive. If the same source was being assessed at a more distant or screened location where the feature was not distinctive against the residual acoustic environment then the acoustic feature correction would not apply.

The example also does not include a discussion of context, which is particularly important in this case. The description seems to suggest that the long-established factory was part of the residual sound level (perhaps dominating it, depending on how the residual sound level measurement times are interpreted and how the commentary for the ambient sound level is interpreted). This should be brought out in the discussion of context, perhaps referring to local perceptions of an existing factory and why the existing factory is apparently not a source of adverse impact. It is also important to ensure that any discussion of context is only relevant at the assessment position and may not be the same as at the alternative location, for instance the residual sound as well as the background sound.

A.6 Examples 6, 7 and 8: Intermittent sources close to dwellings

The three Examples 6, 7 and 8 identify three situations that **'show how similar sound levels can produce different results, depending primarily upon the context in which the sound occurs'**. In all three examples, the same source is used; an item of mechanical equipment, operating intermittently 24 hours per day at commercial premises where other equipment is operating elsewhere. The variation in levels over time is identical in all three examples, however the absolute levels are not.

Example 7 measurement data follows the same time history variation as in Example 6 but 3 dB higher. Similarly, Example 8 measurement data follows the same time history as Example 6 but 5 dB higher.

There is also a key difference in the time period being assessed. Examples 6 and 8 deal with assessing the impact on people who may be going to sleep, whereas Example 7 deals with assessing the impact on people who may be outside during the evening. As a result, Example 7 uses a 1-hour reference time period whereas Examples 6 and 8 use a 15-minute reference time period.

Each example uses a single 31-minute recording to evaluate the specific sound level, the background sound level, and the rating level. The measurement position in Examples 6 and 8 is 4 m from the main dwelling, but in Example 7 is at a neighbour's property. It is not clear why a differing measurement position is used.

It is stated that this 31-minute sample is representative of normal operations, but there is not any justification or explanation for this. At face value this seems unlikely, given the variable and intermittent nature of the specific and residual sound sources, as well as the residual sound. When conducting an assessment, it should not be assumed without justification that any given 31-minute measurement (or similar) will be representative of the full range of normal operations for a given source. Sound levels of intermittent sources recorded over a short period are highly sensitive the number of instances of the specific source occurring. A sample of 31 minutes is also an unusual measurement time to use as the basis for an assessment, particularly given the 1-hour reference time period for the evening period. The uncertainty in this measurement appears to be very high.

The measurement is said to have taken place between 00:49 and 01:20 in Examples 6 and 8, but between 21:49 and 22:20 in Example 7. Given the period of interest in Examples 6 and 8 specifically relates to **'residents who might be going to sleep'**, 00:49-01:20 appears to be very late in the night to make this assessment and may be more appropriate to assessing the impact in terms of awakenings. The time period selected in Example 7 appears to be more appropriate for people **'who might be outside during the late evening'**, but this does not consider the levels earlier or later in the evening, which are likely to be pertinent to the assessment.

The perceptibility of the acoustic character of the specific source is different in each example. In all three examples, a just perceptible tone and impulsivity are present at the assessment location, outside the dwelling. However, in Example 6, no acoustically distinguishing character is considered perceptible in the bedroom of the receptor, and as such there is no character correction applied. In Example 7, an external listener position is of interest, so a 2 dB correction for tonality and a 3 dB correction for impulsivity are applied. In Example 8 the tone and impulsivity are clearly audible outside, so 4 dB and 6 dB corrections are applied respectively. It is notable that despite the source being intermittent, no intermittency penalties are applied.

Due to the intermittent nature of the specific source, and the varying reference time periods, a 13 dB on-time correction is applied in Example 7, whereas a 10.8 dB on-time correction is applied in Examples 6 and 8. As a result of this, and the aforementioned character corrections, there are varying outcomes to the numerical assessment in each example, despite the same time variation in the measurement. The numerical component of the examples results in outcomes of +2 dB, 0 dB, and +7 dB for Examples 6, 7 and 8 respectively.

Despite the intention of these examples being to demonstrate how similar sounds can produce **'different results depending primarily on the context in which the sound occurs'**, the differences between these examples are largely considered to be acoustical factors, including the on-time corrections and acoustic character corrections, rather than contextual factors. There is only limited discussion or consideration for the context in these examples.

There is similarly little consideration of the uncertainty, despite seemingly large uncertainties inherent in the method applied. Given the relatively small difference in the results of these three examples, the high levels of uncertainty are important.

Within each example the relatively high variability in residual sound levels are noted. In Example 6, this is stated somewhat ambiguously but appears to suggest a reduced impact of the specific sound. In Example 7, the high variability in the residual sound is stated to result in increased impact of the specific sound. In Example 8, the variability is mentioned but not discussed. None of these statements are supported with much justification or explanation.

There also appears to be no or very limited discussion of low sound levels. In Example 6, the specific sound level is 24 dB, the residual sound level is 28 dB, and the background sound level is 27 dB, yet no discussion about low sound levels is given. Similarly, there is no discussion of low sound levels in Example 7, despite the specific sound level being 25 dB, the residual sound level being 31 dB, and the background sound level being 30 dB. In Example 8, with specific sound level of 29 dB, residual sound level of 33 dB, and background sound level of 32 dB, the impact due to absolute sound levels is stated as needing to be considered, but no consideration is then given.

Overall these three examples do demonstrate a set of situations whereby the conclusions an be affected by the time period being assessed and the audibility of acoustic character, but they do relatively little to demonstrate appropriate principles of an assessment being applied. There is also a lack of pertinent wider discussions relating to the assessment, such as the context, variable residual levels, and low absolute levels. The conclusions of these assessments are considered to be unreliable, and overall these examples are not considered to be helpful or to represent robust examples of good practice.

A.7 Example 9: Impulsive and intermittent sound acoustic feature corrections

This example assesses a scrapyard sited immediately adjacent to a residential area, where activity produces constant bangs and crashes as well as having tonal features arising from the sources under operation.

The example includes details of measurements during two hours of operation of the site, followed by residual and background sound level measurements over a circa 1h period after the site shuts down.

The specific sound level was measured over a period of 110 minutes. It is not explained why measurements were made over this period rather than over 60 minutes, however it is presumed to follow the principle of Subclause 7.3.15, where the specific sound is intermittent and the on time is equal to or greater than the reference time interval.

The example states that the scrapyard is located adjacent to a residential area, however details of the measurement location are not given. It is not therefore clear whether measurements were made to gauge impacts at dwellings, residential amenity areas, or both. The choice of receptor location could potentially have a bearing on contextual considerations and further supporting information would have been informative. In this example, more than one assessment might have been appropriate.

The example includes a +9 dB correction for impulsivity. This is the maximum permissible penalty for impulses and, following the commentary to Subclause 9.2, should be applied to a sound source that is **highly** impulsive, having regard to both the rapidity of the change in sound level and the overall change in sound level. Given the magnitude of the penalty, at face value, it appears slightly surprising that the example states that the subjective method was considered inadequate and recourse was made instead to the reference method. Further supporting information to inform why a subjective assessment of a highly impulsive source was inappropriate should be provided by the practitioner, following the principle of clause 12 c) of the standard which requires subjective impressions to be reported.

The example also refers to use of an angle grinder that was described as being "prominently tonal", and also met the one-third octave criteria for tonality. When using the objective method for assessing the audibility of tones, Clause 9.3.2 requires that where a tone is identified as present, a correction of 6 dB should be added. Unlike the subjective and reference methods, the objective method doesn't allow scaled corrections.

However, the example applied a +4 dB tonality correction which was, in part, arrived at as the source was not constantly present (15 minutes within 2 hours). The process by which scaling the magnitude of the tone correction having regard to its "on-time" is not given in the example. Clause 9.1 states that certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level and goes on to say that where such features are **present** at the assessment location, a character correction should be added to the specific sound level to obtain the rating level. In other words, the duration of the tone is not required to be assessed, merely whether it is present at the assessment location together with its prominence.

Additionally, scaling the tone correction based on its duration appears to fall outside of Annex C. The method tests for the prominence of a tone by comparing the **'$L_{Zeq,T}$ sound pressure level averaged over the time when the tone is present in a one-third-octave band with the time-average linear sound pressure levels in the adjacent one-third-octave bands'**.

At the assessment Table A.9, it is stated that **'The excess of the rating level over the background sound level is very large and in this instance the uncertainty of the measurement does not have any significance to the outcome of the assessment'**. The consideration of uncertainty discussed in the Pre-Amble would also be applicable in this instance.

A.8 Example 10: The use of a surrogate measurement location

This example relates to a factory in continuous operation that is causing noise complaints from the local population. As the factory cannot be shutdown, measurements of the background and residual sound levels were obtained at a surrogate location.

This is a straightforward example illustrating how a surrogate measurement location may be used, following Subclauses 8.1.2 and 8.4.

The example notes that the ambient sound was measured directly at the assessment location, as noise from the factory was dominant. Some road traffic noise was, however, audible.

The residual and background sound levels were measured at a more distant surrogate location, where factory noise was not significant due to the greater propagation distance as compared with the assessment location and screening from intervening buildings.

At both the assessment and surrogate locations, the level of road traffic was considered to be similar and it was concluded that the acoustic environment was equivalent, with the exception of factory noise.

At both measurement locations, unattended noise monitoring was performed over a one-week period. A weather station was deployed at the surrogate location, to enable data obtained during adverse weather conditions to be excluded. It would have been informative had the example clarified the conditions that were considered sufficiently unfavourable to warrant exclusion of data.

The example states that simultaneous measurements were carried out **'using synchronized sound level meters over a period of one week. This ensured that the weather conditions were identical at both monitoring locations'**. It is not a requirement of BS 4142 that such measurements are carried out simultaneously provided that weather conditions are appropriate for valid measurements in each case.

The example stated that the sound from the factory had a flame roar and a 3 dB penalty was applied following a subjective assessment of the acoustic features of the specific source. As the example stated that the sound was neither tonal nor impulsive, the penalty would appear to have been applied to account for "other sound characteristics" following the commentary on Subclause 9.2. Intermittency would not appear to be the cause of the penalty, as the example states that the furnaces run continuously. Further details of the characteristic features would have made the example more informative.

The example states that uncertainty was minimised by using concurrent measurements and by avoiding adverse weather conditions – presumably the latter actually means that data was excluded as measurements at both locations were unattended. The example doesn't include an assessment table and no data is presented, so it is not possible to gauge the potential effects of uncertainty on the assessment outcome.

A.9 Example 11: Propagation corrections

This example identifies a situation whereby propagation calculations are carried out in parallel with measurements, as a verification check.

The example consists of a small factory 200m from a residential area across open fields where the background and specific sound levels are close together in level, being roughly equally dominated by sound from road traffic, and from the factory.

The description of the sound from the factory of **"generally unlikely to attract attention, but includes a faint mid-frequency tone from an air handling unit"** is assumed to be indicative of the sound at the assessment location.

The measured ambient and residual levels in the example are within 2 dB of each other (50 dB and 48 dB $L_{Aeq(60\ min)}$ respectively), with a background sound level of 45 dB $L_{A90(60\ min)}$ without the factory operating.

The example states that due to the difference between ambient and residual sound levels being less than 3 dB, a second measurement was conducted. However, it should be noted that this is not stated as a rigid cut-off in BS 4142 to indicate excessive uncertainty that would require further measurements. Whether additional measurements are appropriate would depend on the situation and should be justified. Where a robust dataset has been obtained with lengthy or repeated measurements, and in particular where there is little fluctuation in the measured levels, there may be no need for additional measurements (although the addition of further representative data will only decrease uncertainty further). Where a short duration measurement is highly variable, a difference of 10 dB or more could warrant further measurements to reduce uncertainty.

Where a secondary measurement takes place, it is important to carefully select the location and timing of the measurement to provide useful additional information. A secondary measurement with high uncertainty can cast unwarranted doubt on a robust primary measurement.

The example selects a free-field location (Measurement Location 2) 100 m from both the factory and the assessment location where the road was only faintly audible and the acoustic environment was dominated by the factory. When performing propagation calculation for the specific source, it is necessary to perform the calculation only on sound from the specific source. Therefore, it is important that the measurement is sufficiently dominated by the specific sound to assume that there are no contributions from other sources. Alternatively, the residual sound level at this location should be subtracted (with consideration given to the uncertainty in this calculation - see table 1).

At Measurement Location 2, the ambient sound was recorded as 55 dB $L_{Aeq(60\ min)}$, and the residual sound was recorded as 46 dB $L_{Aeq(60\ min)}$. A specific sound level was calculated by logarithmic subtraction to be 54.4 dB $L_{Aeq(60\ min)}$.

Propagation transmission loss calculations were then applied in the form of geometric spreading loss, air absorption, and ground absorption. The calculation method is taken from ISO 9613-2, which assumes downwind propagation, whereas the example quotes still wind conditions; this potential variance should be considered.

The example assumes spherical spreading. In order for this assumption to be valid, the source must be sufficiently in the far-field to enable an assumption that its propagation acts like that of a point source. Where valid assumptions cannot be made, alternative location(s), or detailed modelling of sources at the factory, may be required.

After propagation calculations have been applied, a level of 46 dB $L_{Aeq(60\ min)}$ was reached. It would be good practice to compare this to the original measurements at Measurement Location 1 for validation purposes. Where these values match closely, this is an indication that levels and calculations are likely to be correct. Where these values do not match, this can provide useful information for determining, investigating, and reducing uncertainty.

In this case the original measurements of 50 dB $L_{Aeq(60\ min)}$ ambient sound level and 48 dB $L_{Aeq(60\ min)}$ residual sound level would result in a calculated specific sound level of 45.7 dB $L_{Aeq(60\ min)}$, which is close to 46 dB calculated from the measurement 100 m away. This provides confidence in the results.

After consideration of the levels in the assessment, including a +2 dB acoustic character correction for a slight tonality, the rating level is determined to exceed the background sound level by 3 dB. After accounting for context it is indicated that there is unlikely to be an adverse impact.

The example states that uncertainty was reduced by measuring in still wind conditions over a representative monitoring period. It should be noted that conclusions are therefore likely to be based upon the impact of the factory in still wind conditions, and if other conditions are common, further comment or assessment may be required. The example provides a comment indicating that an adverse impact may occur when the wind is blowing from the source to the receptor, but does not indicate how often this is likely to be the case.

The example further states that the intermediate location has a lower uncertainty than that associated with measuring sound power levels at the factory, which might not accurately account for directionality or planar sources. However, the example doesn't say how this conclusion was reached. Depending on the sources present at the factory and their locations, this conclusion may or may not be valid.

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