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Methods for rating and assessing industrial and commercial sound

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Contents

Summary of pages

This document comprises a front cover, and inside front cover, pages i to iv, pages 1 to 69, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 31 October 2014. It was prepared by Sub-committee EH/1/3, *Residential and industrial noise*, under the authority of Technical Committee EH/1, *Acoustics*. A list of organizations represented on these committees can be obtained on request to their secretary.

Supersession

BS 4142:2014 superseded BS 4142:1997, which has been withdrawn.

BS 4142:2014+A1:2019 supersedes BS 4142:2014, which is withdrawn

Information about this document

BS 4142 was first published in 1967, and was revised in 1990 to align it with elements of ISO 1996. The 1997 edition clarified aspects of the standard in the light of comments from users.

This edition has been prepared under the direction of the Health and Environment Sector Board. The general basis for the standard is derived from the application of previous editions, together with accumulated experience. Some aspects, including guidance on character corrections, are based upon research which has been reported since publication of the previous edition of this standard.

This edition clarifies the application of the standard. New to this edition is the introduction of uncertainty, including good practice for reducing uncertainty. The examples in Annex A have been considerably expanded.

Response to sound can be subjective and is affected by many factors, both acoustic and non-acoustic. The significance of its impact, for example, can depend on such factors as the margin by which a sound exceeds the background sound level, its absolute level, time of day and change in the acoustic environment, as well as local attitudes to the source of the sound and the character of the neighbourhood. This edition of the standard recognizes the importance of the context in which a sound occurs. Great care has, therefore, been taken in the use of the words “sound” and “noise”. Sound can be measured by a sound level meter or other measuring system. Noise is related to a human response and is routinely described as unwanted sound, or sound that is considered undesirable or disruptive.

Text introduced or altered by Amendment No. 1 is indicated in the text by tags [A1) (A1]. Minor editorial changes are not tagged.

Use of this document

It has been assumed in the preparation of this British Standard that the execution of its provisions will be entrusted to appropriately qualified and experienced people, for whose use it has been produced.

Presentational conventions

The provisions of this standard is presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material are presented in smaller italic type, and does not constitute a normative element.

Where words have alternative spellings, the preferred spelling of the Shorter Oxford English Dictionary is used (e.g. “organization” rather than “organisation”).

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

1 Scope

1.1 This British Standard describes methods for rating and assessing sound of an industrial and/or commercial nature, which includes:

a) sound from industrial and manufacturing processes;

b) sound from fixed installations which comprise mechanical and electrical plant and equipment;

c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises; and

d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from fork-lift trucks, or that from train or ship movements on or around an industrial and/or commercial site.

The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

1.2 This standard is applicable to the determination of the following levels at outdoor locations:

a) rating levels for sources of sound of an industrial and/or commercial nature; and

b) ambient, background and residual sound levels,

for the purposes of:

1) investigating complaints;

2) assessing sound from [A1⟩ existing, ⟨A1] proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature; and

3) assessing sound at proposed new dwellings or premises used for residential purposes.

1.3 The determination of noise amounting to a nuisance is beyond the scope of this British Standard.

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

The standard is not intended to be applied to the rating and assessment of sound from:

a) recreational activities, including all forms of motorsport;

b) music and other entertainment;

c) shooting grounds;

d) construction and demolition;

e) domestic animals;

f) people;

g) public address systems for speech; and

h) other sources falling within the scopes of other standards or guidance.

[A1⟩ The methodology set out in Clauses **7**, **8**, and **9** of this standard is not intended to be used to assess the extent of the impact at indoor locations. Internal sound levels can be taken into account as outlined in Clause **11**. ⟨A1]

[A1⟩ The standard is not intended to be applied to the assessment of indoor sound levels. ⟨A1]

The standard is not applicable to the assessment of low frequency noise.

NOTE Information on the assessment of low frequency noise is given in NANR45 [1, 2].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

BS EN 60942, *Electroacoustics — Sound calibrators*

BS EN 61260, *Electroacoustics — Octave-band and fractional-octave-band filters*

BS EN 61672-1, *Electroacoustics — Sound level meters — Part 1: Specifications*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

NOTE All the measurements and values used throughout this standard are "A"-weighted. Where "A" weighting is not explicit in the descriptor, it is to be assumed in all cases, except where it is clearly stated that it is not applicable, as in the case of tones.

3.1 acoustic environment

sound from all sound sources as modified by the environment

[SOURCE: BS ISO 12913-1:2014, **3.4**]

3.2 ambient sound

totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far

NOTE The ambient sound comprises the residual sound and the specific sound when present.

3.3 ambient sound level, $L_a = L_{Aeq,T}$

equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T

NOTE The ambient sound level is a measure of the residual sound and the specific sound when present.

3.4 background sound level, $L_{A90,T}$

A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T, measured using time weighting, F, and quoted to the nearest whole number of decibels

3.5 equivalent continuous A-weighted sound pressure level, $L_{Aeq,T}$

value of the A-weighted sound pressure level in decibels of continuous steady sound that, within a specified time interval, $T = t_2 - t_1$, has the same mean-squared sound pressure as a sound that varies with time, and is given by the following equation:

$$L_{\text{Aeq},T} = 10\lg_{10}\left[\left(1/T\right)\int_{t_1}^{t_2}\left(p_{\text{A}}(t)^2 / p_0^{\ 2}\right)\text{d}t\right] \quad (1)$$

where:

p_0 is the reference sound pressure (20 μPa); and

$p_A(t)$ is the instantaneous A-weighted sound pressure (Pa) at time t

NOTE The equivalent continuous A-weighted sound pressure level is quoted to the nearest whole number of decibels.

3.6 measurement time interval, T_m

total time over which measurements are taken

NOTE This may consist of the sum of a number of non-contiguous, short-term measurement time intervals.

3.7 rating level, $L_{Ar,Tr}$

specific sound level plus any adjustment for the characteristic features of the sound

3.8 reference time interval, T_r

specified interval over which the specific sound level is determined

NOTE This is 1 h during the day from 07:00 h to 23:00 h and a shorter period of 15 min at night from 23:00 h to 07:00 h.

3.9 residual sound

ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound

3.10 residual sound level, $L_r = L_{Aeq,T}$

equivalent continuous A-weighted sound pressure level of the residual sound at the assessment location over a given time interval, T

3.11 specific sound level, $L_s = L_{Aeq,Tr}$

equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, T_r

3.12 specific sound source

sound source being assessed

4 Preparation

The assessor should gain a sufficient understanding of the situation (context) to be rated and assessed by conducting an appraisal, as appropriate, in order to:

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

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

c) identify potential measurement locations;

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

e) where a new development is to be assessed, understand what kind of sound a new industrial [A1) and/or commercial (A1] source would introduce, or what potential impact would be imposed from an existing source on a new sensitive receptor.

5 Instrumentation

5.1 General

Select systems for measuring sound pressure levels, including microphone(s), cable(s), windscreen(s), recording devices and other accessories which conform to BS EN 61672-1, Class 1, for free-field application, as appropriate. Filters, where used, should conform to BS EN 61260, Class 1, and sound calibrators to BS EN 60942, Class 1.

A1 *Text deleted* A1

5.2 Verification

Demonstrate conformity of the measuring system, filters where appropriate and the sound calibrators with the requirements of 5.1 by means of valid certificates showing conformity to each relevant standard following testing according to the appropriate part of that standard.

NOTE 1 It is recommended that sound calibrators are calibrated at intervals not exceeding 1 year, conformity of the measuring systems with BS EN 61672-1 is verified at intervals not exceeding 2 years, and the conformity of filters with BS EN 61260 is verified at intervals not exceeding 2 years.

NOTE 2 A1 It is also acceptable to verify measuring systems in accordance with BS 7580-1. A1

6 Measurement procedure

6.1 Field calibration check

At the beginning of every measurement session check the calibration of the measuring system at one or more frequencies in accordance with the manufacturer's instructions, by means of a sound calibrator and check the calibration value at the end of the measurement. Where the difference between the initial calibration value, any subsequent calibration check, and a final calibration check on completion of measurements exceeds 0.5 dB, treat with caution the results of measurements obtained for any period to which this relates .

NOTE The level of acceptable calibration drift needs to be considered in the context of the entire measurement period. A calibration drift exceeding 0.5 dB might be considered acceptable for an unattended measurement system that has been deployed for several days between calibration checks. In this case, the drift should be reported. Where the drift is 1 dB or more, the measurement chain should be thoroughly investigated to determine the source of the drift. If a fault in the sound measuring system has been identified, then the veracity of the data should be treated with extreme caution.

6.2 Measurement locations

Choose outdoor measurement locations that will give results that are representative of the ambient sound and residual sound at the assessment location(s). Make the measurement of the ambient sound level, the residual sound level and the background sound level at a height of 1.2 m to 1.5 m above the ground, unless there is a specific reason to use an alternative height (which should be justified), and under similar conditions, e.g. similar influence of reflections and measurement height above the ground. Where practical, minimize the influence of reflections by making the measurements at least 3.5 m from any reflecting surface other than the ground.

Where it is necessary to undertake measurements above ground floor level, choose a location which is approximately 1 m from the facade on the relevant floor of the building if it is not practical to make the measurements at least 3.5 m from the facade at this elevation.

NOTE When measurements for distant sources are made at 1 m from a facade, then the measured level can be adjusted to an equivalent free-field level by subtracting a 3 dB correction factor. For sources that are relatively close or not perpendicular to the facade the correction may be 1 dB or 2 dB, in which case the reasons for not using a correction of 3 dB should be explained.

Record the measurement location, height and the distance from any reflecting structure other than the ground.

6.3 Precautions against interference

Take precautions to minimize the influence on the measurements from sources of interference such as:

a) wind passing over the diaphragm of the microphone of a sound measuring system, which can generate interference (see **6.4**);

b) rain falling on the microphone windshield or nearby surfaces, which can cause interference (see **6.4**, Clause **10** and Annex B);

c) electrical and electromagnetic interference, which can be caused in the sound measuring system by, for example, nearby power cables or radio transmitters; and

d) temperature (see **6.4**).

An effective windshield should be used to minimize turbulence at the microphone.

NOTE Windshields are generally effective up to windspeeds of [A1) 5 m/s (A1].

6.4 Weather conditions

Record the weather conditions that could affect measurements. Monitor wind speed at the measurement location, using an anemometer, and record the wind speed together with the wind direction. Exercise caution when making measurements in poor weather conditions such as wind speeds greater than [A1) 5 m/s (A1].

Visually estimate cloud cover by eye as either a percentage of sky covered by cloud or in oktas. Record all forms of precipitation together with the period over which the precipitation occurred, having regard to how this might affect uncertainty (see Clause **10** and Annex B).

Record the temperature at the measurement location, in °C, at the beginning and the end of the measurement period, and at any other appropriate time if there is a change in the weather conditions.

Where appropriate, use instruments for measuring meteorological parameters during long-term unattended measurements by means of a logging meteorological station at the measurement location.

NOTE 1 Weather conditions can affect sound levels by influencing sound propagation or generating sound which can be pertinent to the assessment.

NOTE 2 Whilst regional weather forecasts are useful in planning when to measure, local conditions can often vary significantly from the regional forecast. Forecasts should not be used instead of site measurements of the actual weather during the survey.

NOTE 3 It might be appropriate to make more than one assessment to account for varying weather conditions.

7 Specific sound level

7.1 General

Determine the specific sound level at the assessment location(s) as a discrete entity, distinct and free of other influences contributing to the ambient sound, in accordance with **7.3**. Report in detail the methods used.

Ensure that all sample measurements are representative of the period of interest.

7.2 Reference time interval

Evaluate the specific sound over an appropriate reference time interval, T_r:

a) 1 h during the day; and

b) 15 min during the night.

NOTE 1 For the purposes of this standard, daytime is typically between 07:00 h and 23:00 h and accordingly night-time is between 23:00 h and 07:00 h.

NOTE 2 The shorter reference time interval at night means that short duration sounds with an on time of less than 1 h can lead to a greater specific sound level when determined over the reference time interval during the night than when determined during the day.

7.3 Determination of the specific sound level

NOTE Any rounding is to be done on the basis that a value of 0.5 is rounded up.

7.3.1 Measure the ambient sound level, distinguishing the specific sound from the residual sound. Minimize the influence of sound from other sources by measuring at times and during intervals when the residual sound has subsided to typically low levels.

Where the residual sound level fluctuates by an amount that materially affects the calculated specific sound level, report this.

NOTE The effects could potentially be minimized by measuring at a number of locations and/or periods, or by measuring close to the source and calculating the level at the assessment location(s).

7.3.2 Measure the residual sound level in the absence of the specific sound.

7.3.3 Correct for the effect of the residual sound by using the following formula:

$$L_s = 10\lg(10^{L_a/10} - 10^{L_T/10}) \tag{2}$$

where:

L_s is the specific sound level;

L_a is the ambient sound level; and

L_r is the residual sound level.

NOTE 1 When measuring the residual sound level, all other conditions should be similar to the conditions that exist when the ambient sound level measurements are taken with the specific sound present.

NOTE 2 Where the variability in the residual sound level may be of significance the effect of such uncertainty should be considered as part of the assessment.

If the difference between the ambient sound level and the residual sound level is ≤3 dB, then see 7.3.6 and 7.3.7.

NOTE 3 This can be applicable where there is a greater difference if the residual or specific sound levels have a high degree of variability (see 7.3.13 and 7.3.15).

7.3.4 Where possible, determine the specific sound level by measurement of the ambient sound level and the residual sound level at the assessment location(s).

NOTE It might be appropriate to take measurements if there are periods of low residual sound (such as at night or at weekends) when the specific sound would not normally occur but might be turned on for measurement purposes. The specific sound should as far as is practicable be representative of typical operating conditions.

7.3.5 Where it is not possible to determine the specific sound level by measurement of the ambient sound level and the residual sound level at the assessment location(s), for example, because the difference between the ambient sound level and the residual sound level is ≤3 dB, determine the specific sound level by a combination of measurement and calculation. Report the method of calculation in detail and give the reason for using it.

NOTE In some cases, measurements can be supplemented by calculations. Calculations are often more reliable than a single short-term measurement when long-term averages are to be determined and in other cases where it is impossible to carry out measurements because of high residual sound levels. In case of the latter, it is sometimes convenient to carry out the measurements closer to the source and then use a calculation method to estimate the specific sound level at the assessment location(s).

7.3.6 Determine the specific sound level by calculation alone if measurement is not practicable, for example if the source is not yet in operation. In such cases, report the method of calculation in detail and give the reason for using it.

NOTE 1 When calculating rather than measuring sound pressure levels, it is necessary to have appropriate representative data on source sound emission, for example as a source sound power level (including source directivity), and the position of any point source(s) creating the same sound pressure levels in the environment as the real source. Often, such data are given in established calculation models but in other cases it is necessary that they be determined in each individual case.

NOTE 2 Using a suitable method for the sound propagation from source to receiver, the sound pressure level at the assessment point can be calculated. It is necessary to relate the sound propagation to well-defined meteorological and ground conditions. Most calculation models refer to neutral or favourable sound propagation conditions, as other propagation conditions are much more difficult to predict. The acoustic impedance of the ground is also important, in particular at large distances and low source and receiver heights.

7.3.7 Determine the specific sound level as separate component parts when:

a) the influence of other sound sources can be avoided only by measuring samples of the specific sound; or

b) the specific sound is composed of contributions from several sources which have been measured separately and, if necessary, corrected for propagation effects.

7.3.8 Determine the equivalent continuous A-weighted sound pressure level of the specific sound, $L_{\mathrm{Aeq},T}$, over time interval, T, from the equivalent continuous A-weighted sound pressure levels of its components $L_{\mathrm{Aeq},Ti}$ according to equation (3).

$$L_{\mathrm{Aeq},T} = 10\lg_{10}\left[\left(1/T\right)\sum T_i 10^{0.1L_{\mathrm{Aeq},Ti}}\right] \quad (3)$$

where:

$T = \sum T_i$ if components are sequential; and

T = maximum value of T_i if components are concurrent.

NOTE 1 The time interval, T, may contain intervals, T_i, during which the specific sound is off and the specific sound level is therefore nil.

Ensure that the measurement time intervals are long enough to obtain representative values of the equivalent continuous A-weighted sound pressure level.

NOTE 2 The separate components may be sequential, such as when measuring during troughs in the residual sound, or concurrent, such as when measurements are made close to separate sub-sources which normally operate concurrently and combine to produce a composite sound further away.

7.3.9 Determine the specific sound level over a time interval which reflects all significant temporal and level variations of the specific sound.

NOTE If the sound is steady, a short sample measurement is sufficient. If it is cyclic or intermittent or varies randomly, a longer sample is required to characterize it. It might be necessary to investigate the sound over relatively long periods to select an appropriate, representative measurement time interval.

7.3.10 If the measurement time interval, T_m, is equal to the reference time interval, T_r (see 7.2), measure the equivalent continuous A-weighted sound pressure level, $L_{Aeq,Tm}$, take this value to be L_a, correct for the influence of residual sound according to equation (2), and assign the result to the specific sound level.

7.3.11 If the specific sound is continuous, such that measurements over the time interval $T_m(<T_r)$ are representative of measurements over the reference time interval, T_r, measure the equivalent continuous A-weighted sound pressure level, $L_{Aeq,Tm}$, take this value to be L_a, correct for the influence of residual sound according to equation (2), and assign the result to the specific sound level.

7.3.12 If the specific sound fluctuates at random, select the measurement time interval, T_m, to give a reliable estimate of the equivalent continuous A-weighted sound pressure level over the reference time interval, T_r, measure the equivalent continuous A-weighted sound pressure level, $L_{Aeq,}T_m$, take this value to be L_a, correct for the influence of residual sound according to equation (2), and assign the result to the specific sound level.

7.3.13 If the specific sound is continuous and cyclic with a period less than or equal to the reference time interval, T_r, select the measurement time interval, T_m, to cover a whole number of complete cycles, measure the equivalent continuous A-weighted sound pressure level, $L_{Aeq,Tm}$, take this value to be L_a, correct for the influence of residual sound according to equation (2), and assign the result to the specific sound level (see Figure 1).

NOTE If continuous measurements over the measurement time interval, T_m, cannot be made, short-term measurement time intervals should be selected, so that each represents a part of a cycle and, together, they represent a complete cycle or number of cycles.

7.3.14 If the specific sound is intermittent and either steady or cyclic and the reference time interval, T_r, is over a representative time, and the on time is less than the reference time interval, determine the on time, T_o, and select the measurement time interval, $T_m \leq T_o$, to obtain a representative value for the equivalent continuous A-weighted sound pressure level $L_{Aeq,}T_m$, for the sound while it is on (see Figure 2). Take this value to be L_a and calculate the specific sound level as follows:

$$L_s = 10\lg(10^{L_a/10} - 10^{L_T/10}) + 10\lg(T_o / T_r) \quad (4)$$

Figure 1 — *Selecting the measurement time interval*

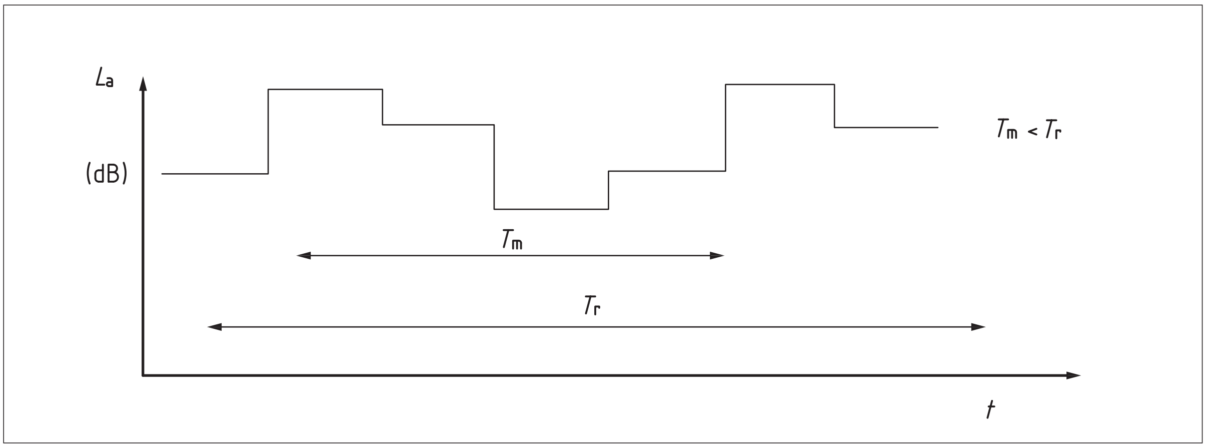
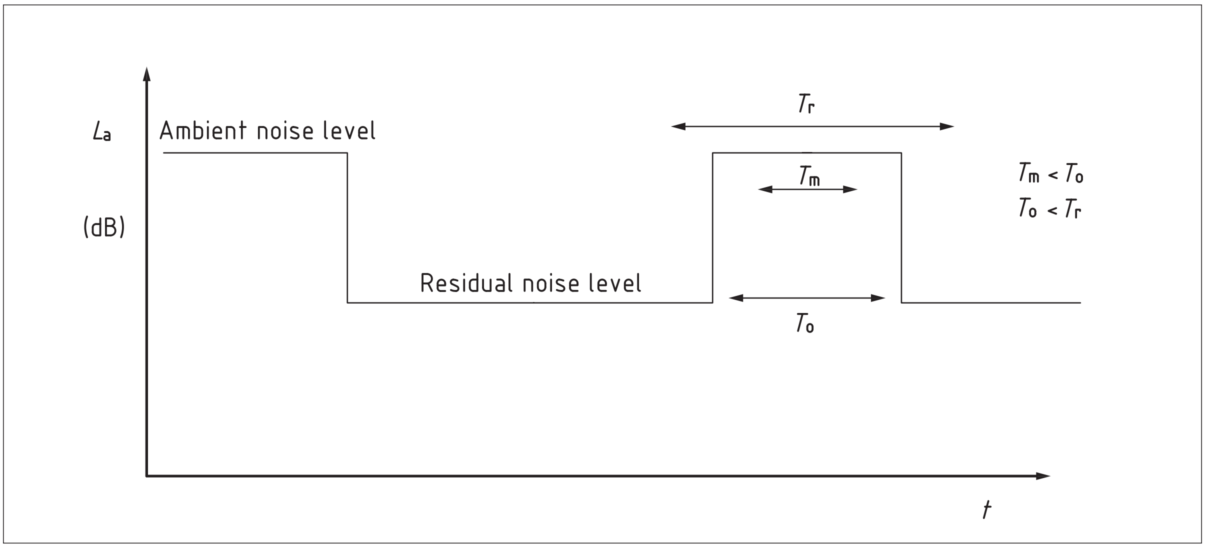
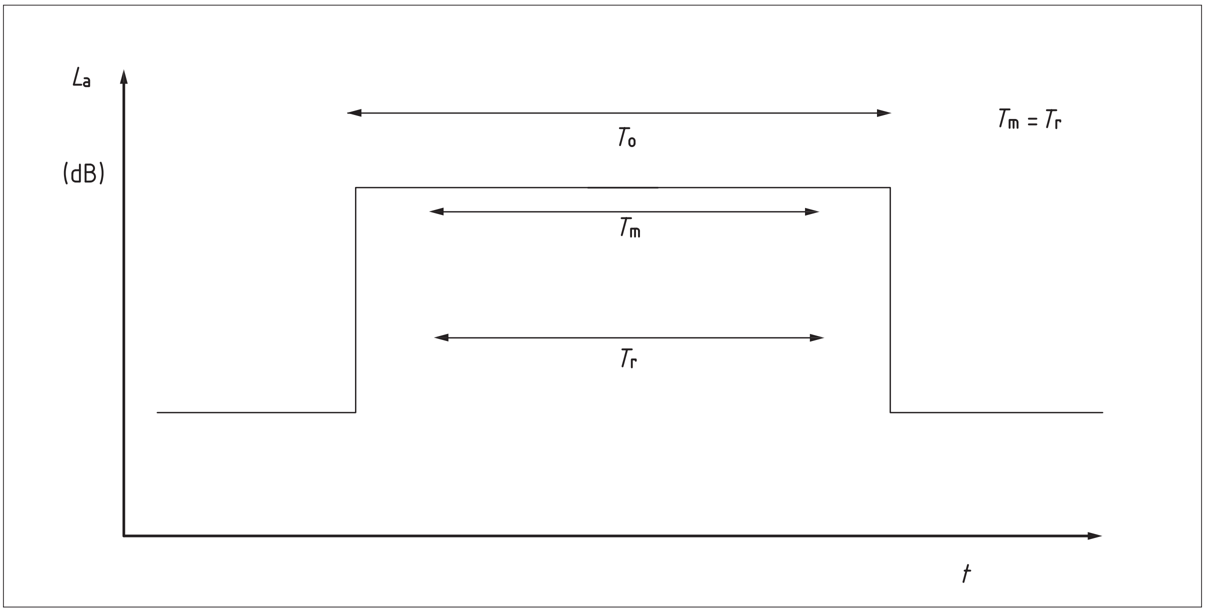


Figure 2 — *Selecting the measurement time interval*



7.3.15 If the specific sound is intermittent or cyclic, and the reference time interval is over a representative time, and the on time is equal to or greater than the reference time interval, select the measurement time interval, T_m, to obtain a representative value for the equivalent continuous A-weighted sound pressure level $L_{Aeq,Tm}$, and take this value to be L_a. Correct for the influence of residual sound according to equation (2), and assign the result to the specific sound level (see Figure 3).

Figure 3 — *Selecting the measurement time interval*



8 Background sound level

8.1 General

COMMENTARY ON ***8.1***

The background sound level is an underlying level of sound over a period, T, and might in part be an indication of relative quietness at a given location. It does not reflect the occurrence of transient and/or higher sound level events and is generally governed by continuous or semi-continuous sounds.

In using the background sound level in the method for rating and assessing industrial and commercial sound it is important to ensure that values are reliable and suitably represent both the particular circumstances and periods of interest. For this purpose, the objective is not simply to ascertain a lowest measured background sound level, but rather to quantify what is typical during particular time periods.

Among other considerations, diurnal patterns can have a major influence on background sound levels and, for example, the middle of the night can be distinctly different (and potentially of lesser importance) compared to the start or end of the night-time period for sleep purposes. Furthermore, in this general context it can also be necessary to separately assess weekends and weekday periods.

Since the intention is to determine a background sound level in the absence of the specific sound that is under consideration, it is necessary to understand that the background sound level can in some circumstances legitimately include industrial and/or commercial sounds that are present as separate to the specific sound.

Care is necessary in circumstances where background sound levels are low to ensure that self-generated and electrical noise within the measurement system does not unduly influence reported values, which may be the case if the measured background sound levels are less than 10 dB above the noise floor of the measuring system.

8.1.1 As appropriate, for each of the following situations, conduct background sound level measurements under weather conditions that are representative and comparable to the weather conditions when the specific sound occurs or could occur:

a) a new specific sound source is to be commissioned (see **8.2**); or

b) a change or modification is to be made to an existing sound source (see **8.2**); or

c) there is an existing specific sound source not operating continuously (see **8.3**);or

d) there is an existing specific sound source operating continuously (see **8.4**); or

e) a new noise-sensitive receptor is being introduced to an environment already experiencing, or that will at a future time experience, industrial and/or commercial sound (see **8.5**).

8.1.2 Where possible, measure the background sound level at the assessment location(s). If this is not possible measure at an alternative location where the residual sound is comparable to the assessment location(s). A detailed justification for considering this should be reported.

NOTE In determining whether an alternative location is suitable for carrying out measurements of the background sound level it is important to take account of all contributing factors that might influence the measurement and assessment procedure. As far as is practicable, uncertainty in any measurement at an alternative location should be minimized and the extent of uncertainty be reported.

8.1.3 Ensure that the measurement time interval is sufficient to obtain a representative value of the background sound level for the period of interest. This should comprise continuous measurements of normally not less than 15 min intervals, which can be contiguous or disaggregated.

8.1.4 The monitoring duration should reflect the range of background sound levels for the period being assessed. In practice, there is no “single” background sound level as this is a fluctuating parameter. However, the background sound level used for the assessment should be representative of the period being assessed.

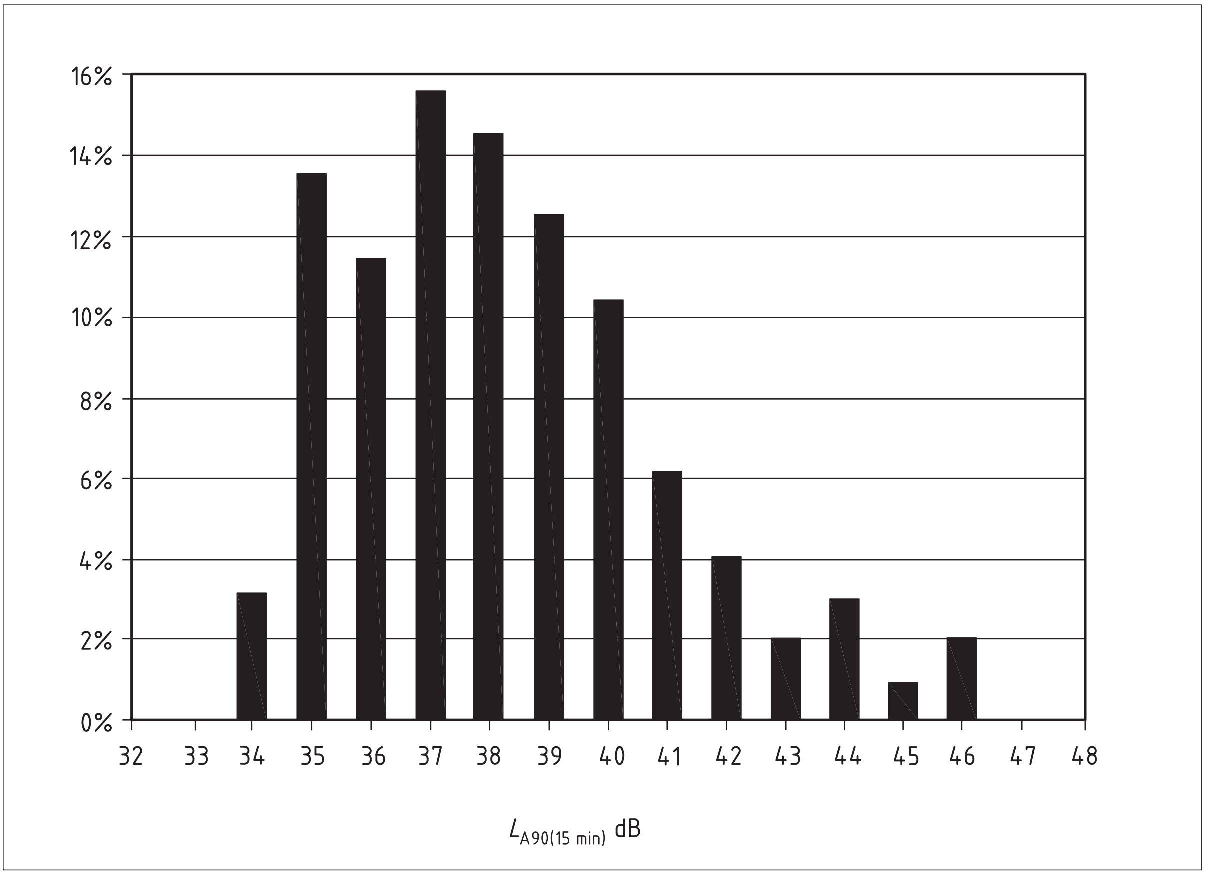
NOTE 1 To obtain a representative background sound level a series of either sequential or disaggregated measurements should be carried out for the period(s) of interest, possibly on more than one occasion. A representative level should account for the range of background sound levels and should not automatically be assumed to be either the minimum or modal value.

NOTE 2 The mean average of a series of measured background sound levels is not numerically equal to the overall period background sound level that would otherwise be obtained by a single measurement spanning individual measurement periods.

NOTE 3 Background sound can be significantly affected by meteorological conditions, particularly where the main sources of residual sound are remote from the assessment location(s).

NOTE 4 Figure 4 shows an example of a statistical analysis of the results of all the measurement periods in order to determine a background sound level. For this distribution of the data an $L_{A90(15\ min)}$ of 37 dB was considered to be representative and in this instance was also the most commonly occurring value.

Figure 4 — *Example of a statistical analysis to determine the background sound level*



8.1.5 To fully understand the context in which the sound from an industrial and/or commercial source(s) is being assessed, describe and report the sources of sound which comprise the acoustic environment.

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

Measure the background sound level at times when the specific sound source(s) is intended to be operated.

8.3 Existing specific sound source(s) not operating continuously

Measure the background sound:

a) during a temporary shutdown of the specific sound source(s); or

b) during a period immediately before or after the specific sound source(s) operate(s); or

c) at times when the specific sound is absent but may otherwise be present over the period of interest.

8.4 Existing specific sound source(s) operating continuously

Measure the background sound at a location which is not subject to the specific sound and where the residual sound is considered to be comparable to that of the assessment location. Justification for considering this should be reported.

8.5 Introduction of a new noise-sensitive receptor

Measure the background sound at the intended location of any new noise-sensitive receptor(s) in the absence of any specific sound.

NOTE Where a new noise-sensitive receptor is introduced and there is extant industrial and/or commercial sound, it should 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.

8.6 Precision when reporting the sound level measured

There can be variability in the derivation of statistical parameters, so use integers when expressing the background sound level.

NOTE 1 A background sound level expressed to a precision of one decimal place implies incorrectly that the background sound level is exactly that value.

NOTE 2 Rounding is to be done on the basis that a value of 0.5 is rounded up.

9 Rating level

9.1 General

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. Where such features are present at the assessment location, add a character correction to the specific sound level to obtain the rating level. This can be approached in three ways:

a) subjective method;

b) objective method for tonality;

c) reference method.

NOTE 1 Sound with prominent impulses has been shown to be more annoying than continuous types of sound (without impulses or tones) with the same equivalent sound pressure level.

NOTE 2 The rating level is equal to the specific sound level if there are no such features present or expected to be present.

9.2 Subjective method

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

Correct the specific sound level if a tone, impulse or other characteristic occurs, or is expected to be present for new or modified sound sources.

NOTE 1 The prominence of tonal or impulsive sound from a source can be masked by residual sound. In many cases the amount of masking varies as the residual sound changes in level and possibly character. The source's tonal and/or impulsive characteristics could also vary with time.

Consider 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.

COMMENTARY ON ***9.2***

Tonality

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.

Impulsivity

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.

NOTE 2 [A1) *If characteristics likely to affect perception and response are present in the specific sound, within the same reference period, then the applicable corrections ought normally to be added arithmetically. However, if any single feature is dominant to the exclusion of the others then it might be appropriate to apply a reduced or even zero correction for the minor characteristics.* (A1]

Intermittency

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

[A1) ***Other sound characteristics***

Where the specific sound features characteristics that are neither tonal nor impulsive, nor intermittent, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied. (A1]

9.3 Objective methods

9.3.1 General

If the subjective method is not sufficient for assessing the audibility of tones in sound or the prominence of impulsive sounds, use the one-third octave method in 9.3.2 and/or the reference methods in 9.3.3, as appropriate.

The precision used in the assessment should be appropriate to the method chosen and the uncertainties associated with it. If the reference method approach is adopted it might be appropriate to work to a precision of one decimal place and then round the rating level to the nearest integer value. If an approximation value is used then integer values should be used throughout.

NOTE 1 The uncertainty in assessing community response to sound from industrial and commercial sources makes the use of a precision of one decimal place inappropriate.

NOTE 2 Rounding is to be done on the basis that a value of 0.5 is rounded up.

9.3.2 One-third octave method

Identify tones using the method given in Annex C, then add a correction of 6 dB if a tone is present.

9.3.3 Reference methods

When the one-third octave method is not sufficient, use the reference method for assessing the audibility of tones given in Annex D, which produces a penalty on a sliding scale from 0.0 dB to 6.0 dB.

Use the reference method given in Annex E for measuring the prominence of impulsive sounds, which produces penalties in the range 0.0 dB to 9.0 dB.

NOTE Where tonal and impulsive characteristics are present in the specific sound within the same reference period then these two corrections can both be taken into account. If one feature is dominant then it might be appropriate to apply a single correction. Where both features are likely to affect perception and response, the corrections should normally be added [A1) *arithmetically* (A1].

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10 Uncertainty

10.1 General

Consider the level of uncertainty in the data and associated calculations. Where the level of uncertainty could affect the conclusion, take reasonably practicable steps to reduce the level of uncertainty. Report the level and potential effects of uncertainty.

10.2 Uncertainty of measured values

Report the reasoning for the selected measurement method, together with steps taken to reduce measurement uncertainty.

NOTE The level of uncertainty associated with a measurement of sound level depends upon a number of factors, including:

a) the complexity of the sound source and the level of variability in sound emission from the source;

b) the complexity and level of variability of the residual acoustic environment;

c) the level of residual sound in the presence of the specific sound at the measurement location;

d) the location(s) selected for taking the measurements;

e) the distance between sources of sound and the measurement location and intervening ground conditions;

f) the number of measurements taken;

g) the measurement time intervals;

h) the range of times when the measurements have been taken;

i) the range of suitable weather conditions during which measurements have been taken;

j) the measurement method and variability between different practitioners in the way the method is applied;

k) the level of rounding of each measurement recorded; and

l) the instrumentation used.

An appreciation of the uncertainties in the measurement is likely to lead to a better understanding of the measurement, its potential variability and any implications in the reported findings of the assessment. In such instances, where the level of uncertainty is too great, it might be necessary to repeat measurements or to take other steps to obtain the desired confidence in the results.

Although the level of uncertainty due to the instrumentation system can be quantified, this is unlikely to be practicable for some of the other measurement uncertainties. The level of uncertainty can be reduced by several methods, including taking more measurements, for longer measurement time intervals, on different occasions over longer periods of time, under differing suitable weather conditions. What is appropriate will depend upon the *particular circumstances of each assessment, including the scale of the proposed development and the risk of it causing significant adverse impact. Consideration should be given to any published information that is relevant to the assessment.*

10.3 Uncertainty in calculations

COMMENTARY ON ***10.3***

Uncertainty in calculating sound levels can arise from:

a) uncertainty in any measured sound levels used in the calculations;

b) uncertainty in the operation or sound emission characteristics of the specific sound source and any assumed sound power levels;

c) uncertainty in the calculation method;

d) simplifying the real situation to "fit" the model (user influence on modelling); and

e) error in the calculation process.

Where the sound power level is used for calculating sound pressure levels, it should be representative of the source and the conditions under which the source is expected to operate.

Where possible, use recognized standards to establish the sound power level and the uncertainty (e.g. BS EN ISO 3740 and BS EN ISO 3747). Where it is not possible to use appropriate standards, describe the method of establishing the sound power level, report the uncertainty and state the reasons for using this method.

Use a validated method of calculating sound levels, e.g. ISO 9613-2 or similar. If an alternative calculation method is used, fully describe the method and state the reasons for using this method.

Check the implementation of the calculation method for errors.

For simple cases, e.g. where the level of variability in sound propagation resulting from changes in meteorological conditions is likely to be small, simple calculation methods might be sufficient.

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11 Assessment of the impacts

COMMENTARY ON ***11***

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

Obtain an initial estimate of the impact of the specific sound by subtracting the measured background sound level (see Clause 8) from the rating level (see Clause 9).

NOTE 1 More than one assessment might be appropriate.

a) Typically, the greater this difference, the greater the magnitude of the impact.

b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.

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

NOTE 2 Adverse impacts may include but not be limited to annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact.

Where the initial estimate of the impact needs to be modified due to the context, take all pertinent factors into consideration, including the following.

1) The absolute level of sound. For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.

   Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.

   Where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts, and the margin by which the rating level exceeds the background might simply be an indication of the extent to which the specific sound source is likely to make those impacts worse.

2) The character and level of the residual sound compared to the character and level of the specific sound. Consider whether it would be beneficial to compare the frequency spectrum and temporal variation of the specific sound with that of the ambient or residual sound to assess the degree to which the specific sound source is likely to be distinguishable and will represent an incongruous sound by comparison to the acoustic environment that would occur in the absence of the specific sound. Any sound parameters, sampling periods and averaging time periods used to undertake character comparisons should reflect the way in which sound of an industrial and/or commercial nature is likely to be perceived and how people react to it.

   NOTE 3 Consideration should be given to evidence on human response to sound and, in particular, industrial and/or commercial sound where it is available. A number of studies are listed in the “Effects on humans of industrial and commercial sound” portion of the “Further reading” list in the Bibliography.

3) The sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions, such as:

   i) facade insulation treatment;

   ii) ventilation and/or cooling that will reduce the need to have windows open so as to provide rapid or purge ventilation; and

   iii) acoustic screening.

12 Information to be reported

Report the following, as appropriate.

a) Statement of qualifications, competency, professional memberships and experience directly relevant to the application of this British Standard of all personnel contributing to the assessment.

b) Source being assessed as follows:

   1) description of the main sound sources and of the specific sound;

   2) hours of operation;

3) mode of operation (e.g. continuous, twice a day, only in hot weather);

4) statement of operational rates of the main sound sources (e.g. maximum load setting, 50% max rate, low load setting); and

5) description of premises in which the main sound sources are situated (if applicable).

c) Subjective impressions, including:

1) dominance or audibility of the specific sound; and

2) main sources contributing to the residual sound.

d) The existing context (see Clause **4** and Clause **11**), including an assessment of the sensitivity of the receptor [A1] *Text deleted* [A1].

e) Measurement locations, their distance from the specific sound source, the topography of the intervening ground and any reflecting surface other than the ground, including a photograph, or a dimensioned sketch with a north marker. A justification for the choice of measurement locations should also be included.

f) Sound measuring systems, including calibrator or pistonphone used:

1) type and/or model;

2) manufacturer;

3) serial number; and

4) details of the latest verification test including dates.

g) Operational test:

1) reference level(s) of calibrator, multi-function calibrator or pistonphone; and

2) meter reading(s) before and after measurements with calibrator, multi-function calibrator or pistonphone applied.

h) Weather conditions, including:

1) wind speed(s) and direction(s);

2) presence of conditions likely to lead to temperature inversion (e.g. calm nights with little cloud cover);

3) precipitation;

4) fog;

5) wet ground;

6) frozen ground or snow coverage

7) temperature; and

8) cloud cover.

i) Date(s) and time(s) of measurements.

j) Measurement time intervals.

k) Reference time interval(s).

l) [A1] Measured sound level(s):

1) residual sound level(s) and method of determination;

2) ambient sound level(s) and method of determination;

3) specific sound level(s) and method of determination;

4) justification of methods; and

5) details of any corrections applied. A1

m) Background sound level(s) and measurement time interval(s) and in the case of measurements taken at an equivalent location, the reasons for presuming it to be equivalent.

n) Rating level(s):

1) specific sound level(s);

2) any acoustic features of the specific sound; and

3) rating level(s).

o) Excess of the rating level(s) over the measured background sound level(s) and the initial estimate of the impacts.

p) Conclusions of the assessment after taking context into account.

q) The potential impact of uncertainty (see Clause **10**).

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

*NOTE These examples illustrate how the standard could be applied and are not to be taken as a definitive interpretation of how it should be used. It is assumed in all these examples that full information as required in Clause **12** would be included in the report and is not therefore given here.*

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

A factory that has recently become operational works only during the day and produces a continuous, low-level general hum that is steady, not attributable to one specific source of sound and can be heard at the measurement location.

Figure A.1 shows the sound level time history to include 40 min immediately before the factory machinery is turned on, in addition to a sample of the sound caused by the factory. The sound levels both before and after the factory machinery is turned on are relatively steady and continuous.

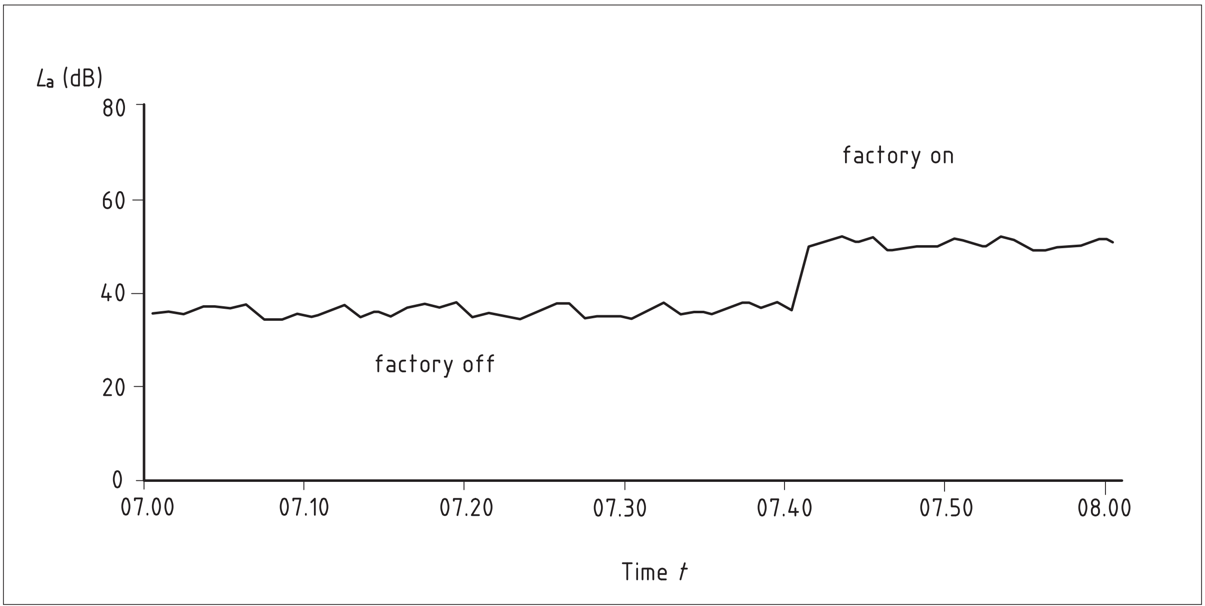
It is reasonable to assume that sample measurements are representative, provided that there is no reason to believe that either the background sound level or the factory sound would significantly change over a longer period of time. It is also reasonable to assume that the background sound level does not change after the machinery is turned on.

The specific sound level in this case was determined by measuring the ambient sound level L_a as an $L_{Aeq(15\ min)}$, as this sample measurement was deemed to be a representative sample of the factory sound.

NOTE A longer measurement period up to 1 h could have been used.

The residual sound level and background sound level were measured when the specific sound was off and when conditions contributing to the fluctuations in the residual sound were similar to those when the ambient sound level was measured. The residual sound level was $L_{Aeq(40\ min)}$ 39 dB with a background sound level of $L_{A90(40\ min)}$ 35 dB.

Figure A.1 — *Sound level variation with time*



The assessment and its results are detailed in Table A.1.

Table A.1 — *Example 1: Assessment*

Results		Relevant clause	Commentary
Measured ambient sound level	$L_{Aeq(15\ min)}$ = 51 dB	7.1 7.3.1	Specific sound source active and the level unaffected by any other sound sources
Residual sound level	$L_{Aeq(40\ min)}$ = 39 dB	7.3.3	Specific sound not active to determine the correction to be made to the measured ambient sound level
Background sound level	$L_{A90(40\ min)}$ = 35 dB	8.1.3 8.3	Measured just before the factory started up; was deemed to be representative of the background sound when the factory was in operation
Assessment made during the daytime, so reference time interval is 1 h		7.2	
Specific sound level	$L_{Aeq(60\ min)}$ = 51 dB	7.3.4 7.3.5	
Acoustic feature correction	+3 dB	9.2	The specific sound is not distinctly tonal, though is otherwise distinctive against the residual acoustic environment.
Rating level	(51 + 3) dB = 54 dB	9.2	The factory produces a continuous steady hum
Background sound level	$L_{A90(40min)}$ = 35 dB	8	Residual sound level was relatively steady
Excess of rating over background sound level	(54 - 35) dB = 19 dB	11	
Assessment indicates likelihood of significant adverse impact		11	
Uncertainty of the assessment	Not significant	10	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

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

This example illustrates the procedure and calculations to be undertaken when the sound to be assessed is not significantly in excess of the residual sound, which in turn does not have any identifiable low level periods in which the specific sound level could otherwise be measured.

This is a similar situation to example 1, but the assessment location is further away from the factory. The background sound level was measured over a 30 min period when the specific sound source was not operating. The measurement of the factory sound was affected by the residual sound. Consequently, a correction has to be made.

At this location the factory sound had no discernible acoustic features.

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. Since the measured ambient sound level is not much in excess of the residual sound level the choice is to apply a correction to the ambient sound level or to measure the ambient sound level on another occasion when the residual sound is lower. An alternative would be to measure the specific sound level closer to the factory at a location where it is much greater than the residual sound level and then calculate the sound level at the receiver location. In this case, because the sound levels are fairly steady and do not vary much over time, the method of correcting the ambient sound level to calculate the specific sound level by removing the contribution of the residual sound was chosen.

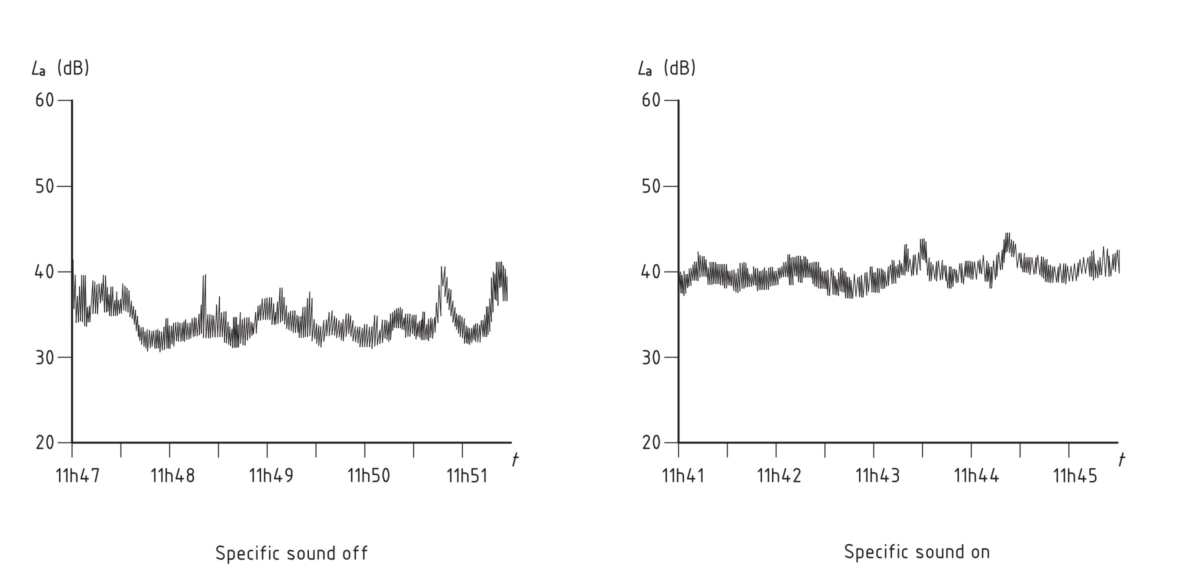
The specific sound was measured over a 20 min period. This was assumed to be representative of any longer term fluctuations in the specific sound. The residual sound level was determined over a similar representative time period of 20 min when the specific sound source was switched off.

The assessment and its results are detailed in Table A.2.

Table A.2 — *Example 2: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	$L_{\text{Aeq(20 min)}}$ = 40 dB	7.3.1	Specific sound on
Residual sound level	$L_{\text{Aeq(20 min)}}$ = 35 dB	7.3.3	Specific sound off to determine the correction to be made to the measured ambient sound level
Background sound level (day)	$L_{\text{A90(30 min)}}$ = 34 dB	8.3	The background sound was measured in a temporary shutdown of the factory, but otherwise representative of normal conditions
Assessment made during the daytime, so the reference time interval is 1 h		7.2	
Specific sound level calculated by correcting the ambient sound level to remove the contribution of the residual sound level	$L_{\text{Aeq(60 min)}}$ = 38 dB	7.3.4	
Acoustic feature correction	0 dB	9.2	No acoustic features were present
Rating level	(38 + 0) dB = 38 dB	9.2	
Background sound level	$L_{\text{A90(30 min)}}$ = 34 dB	8	
Excess of rating over background sound level	(38 – 34) dB = 4 dB	11	
The assessment indicates likelihood of adverse impact		11	Although the excess of rating over background sound level was less than +5 dB, this conclusion is reached by professional judgement, taking context into consideration
Uncertainty of the assessment		10	The measurements were taken under repeatable conditions and the uncertainty in the result will be low.

Figure A.2 — *Measurement of the factory sound affected by the residual noise*



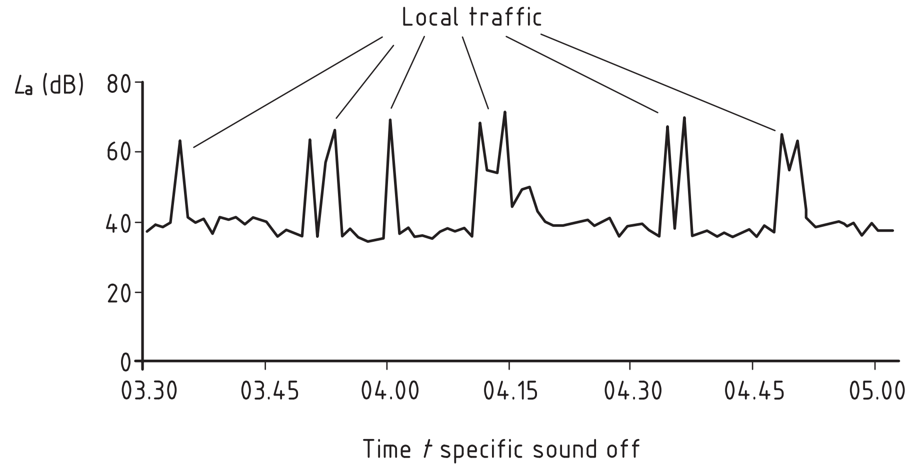
A.3 Example 3: Effect of residual sound

An existing factory installed a machine which has operated during the day without complaint. The operators wish to assess the significance of impact if the machine were to operate at night. The machine operates continuously, emitting discernible but not prominent bangs.

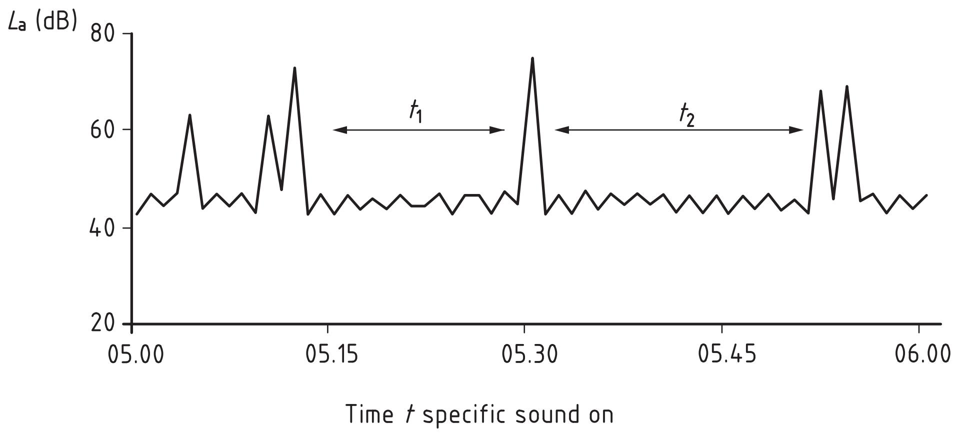
The maximum sound levels were produced by passing traffic and were above the steady sound of the specific sound source. The specific sound source was measured during those periods between passing traffic.

Figure A.3 shows an extract of a 90 min measurement of the residual sound and ambient sound at night. An hour was used thereafter to assess the variability of the specific sound source. The specific sound level was measured during the indicated periods t_1 and t_2 in Figure A.3.

Figure A.3 — *Sound level variations with time*



a) Specific sound off



b) Specific sound on

The assessment and its results are detailed in Table A.4.

Table A.3 — *Example 3: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	$L_{Aeq(15\ min)}$ = 44 dB	7.3.2	The specific sound could clearly be heard during lulls in the passing night-time traffic
Residual sound level	$L_{Aeq(5\ min)}$ = 40 dB	7.3.3	A representative residual sound level is obtained from measurements between traffic pass-bys
Background sound level (night-time)	$L_{A90(60\ min)}$ = 38 dB	8.1.1 8.1.3 8.3	A relatively long measurement period was used owing to varying ambient sound levels caused by traffic. The background sound level can be measured over a longer time than the reference time period or over several periods
Assessment made during the night-time, so the reference time interval is 15 min		7.2	

Table A.3 *(continued)*

Results		**Relevant clause**	**Commentary**
Specific sound level calculated by correcting the ambient sound level to remove the contribution of the residual sound level	$L_{Aeq(15\ min)}$ = 42 dB	7.3.4	
Acoustic feature correction	+3 dB	9.2	This is an estimated correction of +3 dB to account for the character of discernible bangs
Rating level	(42 + 3) dB = 45 dB	9.2	
Background sound level	$L_{A90(60min)}$ = 38 dB	8.3	
Excess of rating over background sound level	(45 - 38) dB = 7 dB	11	Assessment indicates that reduction or mitigation measures are desirable if the machine is to run at night
Assessment indicates a likely adverse impact		11	The context is night-time when there is a greater likelihood of adverse impact
Uncertainty of the assessment		10	The excess of the rating level over the background sound level is not very large and in this instance the uncertainty of the measurement might have some influence on the outcome of the assessment

A.4 Example 4: Source is intermittent and cyclic

A factory on the edge of an industrial estate operates 24 hours a day and is to install a new process that will operate over 20 h from 06:00 h to 02:00 h. Figure A.4 shows a typical cycle of operation over a 1 h period whereby the source is on for two distinct periods of 7 min 45 s and 4 min, respectively.

Switching the plant on and off at a comparable factory that already operates the new process does not indicate any acoustic features that warrant correction for tonality, impulsivity or other sound characteristics at the assessment location.

The background sound level, determined at the nearest residence to the factory that plans to install the process, in terms of $L_{A90(60\ min)}$, was 31 dB at night and 39 dB during the day.

When the sound of the proposed operation was measured at a comparable distance to the factory where it already operates, and under comparable acoustic conditions, the $L_{Aeq(12\ min)}$ was 41 dB. After the ambient sound level was measured, the specific source was turned off and the measured residual sound level was 36 dB.

The assessment and its results are detailed in Table A.4.

Figure A.4 — *Specific sound source cycling on and off*

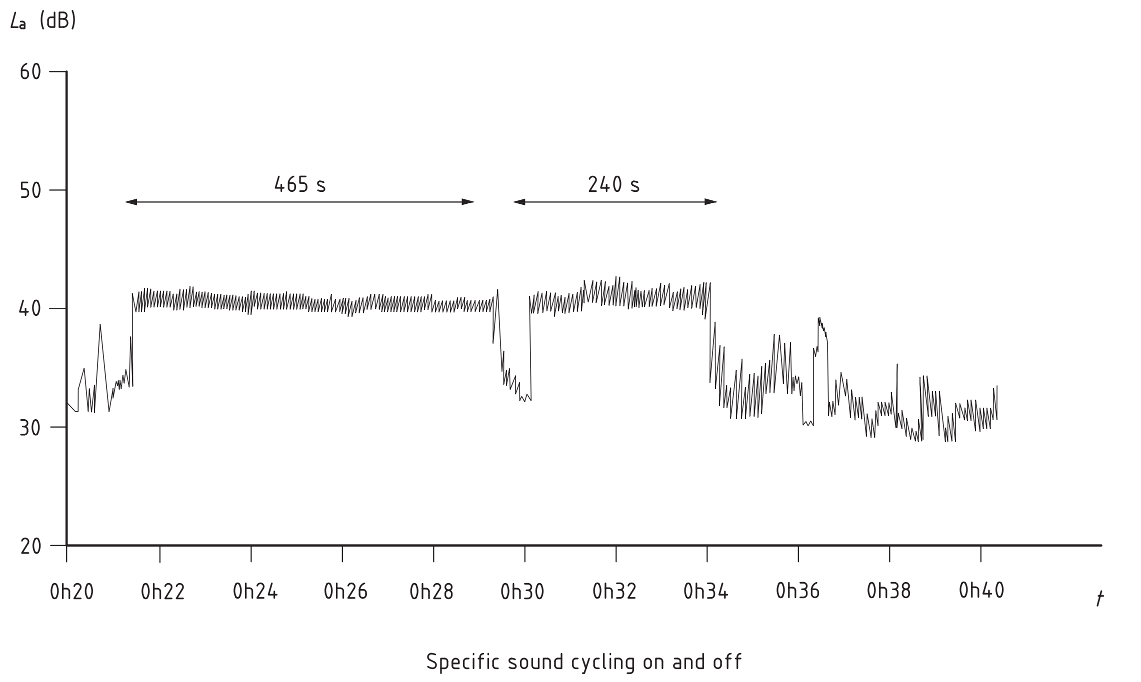


Table A.4 — *Example 4: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	$L_{Aeq(12\ min)}$ = 41 dB	7.1 7.3.1 7.3.10	This includes all cycles of the specific sound
Residual sound level	$L_{Aeq(12\ min)}$ = 36 dB	7.3.3	Measured for the factory where the process already operates when the specific sound was not active
Background sound level (daytime)	$L_{A90(60\ min)}$ = 39 dB	8.1 8.1.3 8.1.4 8.3	The background sound level was measured at the assessment location during the daytime under comparable weather conditions to those that prevailed when the ambient and residual sound were measured at the other factory
Background sound level (night-time)	$L_{A90(15\ min)}$ = 31 dB	8.1 8.1.3 8.1.4 8.3	The background sound level was measured at the assessment location during the night-time after 02:00 h and a statistical analysis was done to determine the typical background sound level
Daytime			
Assessment made during the daytime. The reference time interval is 1 h		7.2	
The total on time during a reference interval is 465 s + 240 s = 705 s			The source is on for two periods as part of its cycle during the reference time interval of 60 min
On time correction (to nearest 0.1 dB as intermediate step in Equation 4 calculation)	10 lg (705/3 600) = -7.1 dB	7.3.15	The specific source is cyclical, the cycle times in total being less than the daytime reference time period. Therefore, an on time correction is applied as in Equation 4
Specific sound level	$L_{Aeq(60\ min)}$ = [10 lg ($10^{4.1} - 10^{3.6}$) – 7.1] dB = 32 dB	7.3.15	Equation 4
Rating level	32 dB	**9.3.4**	No corrections are applied for tonality, impulsivity or other sound characteristics
Background sound level	$L_{A90(60min)}$ = 39 dB	8.1 8.1.3 8.1.4 8.3	

Table A.4 *(continued)*

Results		Relevant clause	Commentary
Excess of rating over background sound level	(32 – 39) dB = -7 dB	11	
Assessment indicates little likelihood of adverse impact		11	The excess of the rating level over the background sound level is -7 dB and in this instance the uncertainty of the measurement does not have any signifance to the outcome of the assessment
Night-time			
Assessment made during the night-time. The reference time period is 15 min		7.2	
The total on time during a reference period is 465 s + 240 s = 705 s			The source is on for two periods as part of its cycle during the reference time of 15 min
On time correction (to nearest 0.1 dB as intermediate step in Equation 4 calculation)	10 lg (705/900) = –1.1 dB		The specific source is cyclical, the cycle time in total being less than the night-time reference time period. Therefore, an on time correction is applied as in Equation 4
Specific sound level	$L_{Aeq(15\ min)}$ = [10 lg ($10^{4.1} - 10^{3.6}$) – 1.1] dB = 38 dB	7.3.15	Equation 4
Rating level	38 dB	**9.3.4**	No corrections are applied for tonality, impulsivity or other sound characteristics
Background sound level	$L_{A90(15\ min)}$ = 31 dB	8.3	
Excess of rating over background sound level	(38 - 31) dB = 7 dB	11	
Assessment indicates a likelihood of adverse impact, which could be significant		11	The excess of the rating level over the background sound level is +7 dB and in this instance the uncertainty of the measurement does not have any significance to the outcome of the assessment

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

This example deals with a situation where the sound that is to be rated emanates from an industrial installation during the night-time and is higher than the residual and background sound levels which cannot be measured at the assessment location.

An industrial installation has operated for many years, but following upgrading of plant has become the subject of complaints from local residents. The plant giving rise to complaints operates continuously throughout the night-time and produces steady, mild to prominent tonal components.

Representative residual and background sound levels were obtained from a series of measurements at an alternative location due to the sound under investigation being continually present at the assessment location. The justification for the alternative location is as follows:

a) the alternative location is the same distance from residual sound sources and sound from the plant is acoustically screened by a significant building structure;

b) the sound from the plant is not distinguishable at the alternative location;

c) measurements of background sound levels and residual sound levels were undertaken during the night-time under the same meteorological conditions as when measurements of the ambient sound level were conducted;

d) a series of contiguous $L_{A90\ (15\ min)}$ measurements were conducted between 11:00 h and 00:15 h with variation in results not exceeding 1 dB;

e) ambient sound at the alternative location comprised the same sources as at the assessment location, other than the specific sound source being rated;

f) both measurement locations have the same ground cover and, other than respective building facades, are free from significant sound reflecting structures;

g) measurement heights above ground level and distances from facades are the same at the two locations;

h) background sound level and residual sound level measurements were conducted over the same period as when the specific sound level was determined; and

i) there were no transient or other influencing noise events.

The specific sound level was measured in terms of $L_{Aeq(15\ min)}$, from 23.00 h onwards.

The assessment and its results are detailed in Table A.5.

Table A.5 — *Example 5: Assessment*

Results		**Relevant clause(s)**	**Commentary**
Measured ambient sound level	$L_{Aeq(15\ min)}$ = 54 dB	7.3.1	Specific sound source on and the level unaffected by any other sound sources
Residual sound level	$L_{Aeq(15\ min)}$ = 40 dB	7.3.3	Determined at an alternative location together with the background sound level)
Background sound level	$L_{A90(15\ min)}$ = 37 dB	8	Determined at an alternative location together with the residual sound level
Assessment made during the night-time, so the reference time interval is 15 min		7.2	
Specific sound level	$L_{Aeq(15\ min)}$ = 54 dB	7.3	No correction required to the measured sound level.
Acoustic feature correction	+4 dB	9.2	The industrial installation produces a continuous, steady whine. Subjective method used to account for a mild to prominent tone

Table A.5 *(continued)*

Results		Relevant clause(s)	Commentary
Rating level	(54 +4) dB = 58 dB	9.2	The industrial installation produces a continuous, steady whine
Background sound level	$L_{A90\,(15\,min)}$ = 37 dB	8	
Excess of rating level over background sound level	(58 - 37) dB = 21 dB	11	
Assessment indicates likelihood of significant adverse impact		11	
Uncertainty of the assessment		10	The excess of the rating level over the background sound level is large and in this instance the uncertainty of the measurement does not have any signifance to the outcome of the assessment

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

COMMENTARY ON ***A.6***

[A1⟩ *Examples 6, 7 and 8 (A.6.1, A.6.2 and A.6.3) use similar sound measurement time profiles but of a different level, with the data for Example 7 being 3 dB higher than Example 6, and that for Example 8 being 5 dB higher than Example 6. Examples 6 and 8 consider the potential impact on residents who might be going to sleep in indoor bedrooms, whereas Example 7 considers the potential impact on residents who might be outside during the late evening. Although the difference between the specific and residual sound levels remains constant for all three examples, the difference between specific and background levels differs depending upon the reference time interval. The difference between the rating and background levels also differs due to the variation in the character correction penalty that is applicable for the three different scenarios.*

These three examples show how similar sound levels can produce different results, depending primarily upon the context in which the sound occurs. ⟨A1]

A.6.1 Example 6: Intermittent sound source operating at night potentially affecting residents indoors, [A1⟩ and producing a relatively low sound level with slight tonality/impulsivity outdoors, but no significant acoustically distinguishing characteristics indoors ⟨A1]

An item of mechanical equipment has been installed at a commercial premises where other plant is also operating elsewhere on site. [A1⟩ This item of mechanical plant operates ⟨A1]intermittently 24 hours a day, producing sound that is identifiable outside the nearest dwelling, particularly when the residual sound falls to lower levels when residents might be going to sleep. At these more sensitive times the sound contains a tone that is just perceptible outside the dwelling and appears to be slightly impulsive when starting operation. However, the slight tonality that is noticeable outdoors is not noticeable indoors and the corresponding change in sound level as the source commences or ceases operation is relatively slight indoors due to masking by other sources of sound within the dwelling and does not attract a listener's attention.[A1⟩ *Text deleted* ⟨A1]

Figure A.5 shows the sound level time history (measured every 100 ms) 4 m from the nearest dwelling for 31 min at night, during which time the sound source was identifiable on five occasions and the residual acoustic environment included typical variations due to sources such as passing and distant vehicles, an aircraft and some animal activity. The specific sound source is located close to the dwelling, so it was not practicable to take measurements closer to it. The identifiable periods when the source was operating and its constant character reduce the uncertainty in calculating the specific sound level from these measurements.

It is reasonable to assume that the operation of the plant throughout the measurement period is representative of normal operation and that the residual acoustic environment was representative of normal conditions at this time.

The L_{Aeq} for the entire measurement period was 40 dB, falling to a residual sound level of around 28 dB at times when no vehicles were passing and the specific source was not operating. The background sound level L_{A90} was measured as 27 dB for the entire measurement period (the specific source being on for such short periods as to be judged not to affect this measurement) and the ambient L_{Aeq} was measured as 36 dB whilst the specific sound source was operating [A1) and no vehicles were passing (A1].

The assessment and its results are detailed in Table A.6.

In addition to the rating/background sound level comparison shown in Table A.6, the primary concern is the potential for disturbance of residents who could be sleeping with open bedroom windows.

Other guidance, such as BS 8233, might also be applicable in this instance. As Figure A.5 shows, the residual acoustic environment varies considerably with time, which also tends to mask sound from the source, reducing its relative significance in comparison with a location where the residual sound level remains relatively steadily around 27 dB.

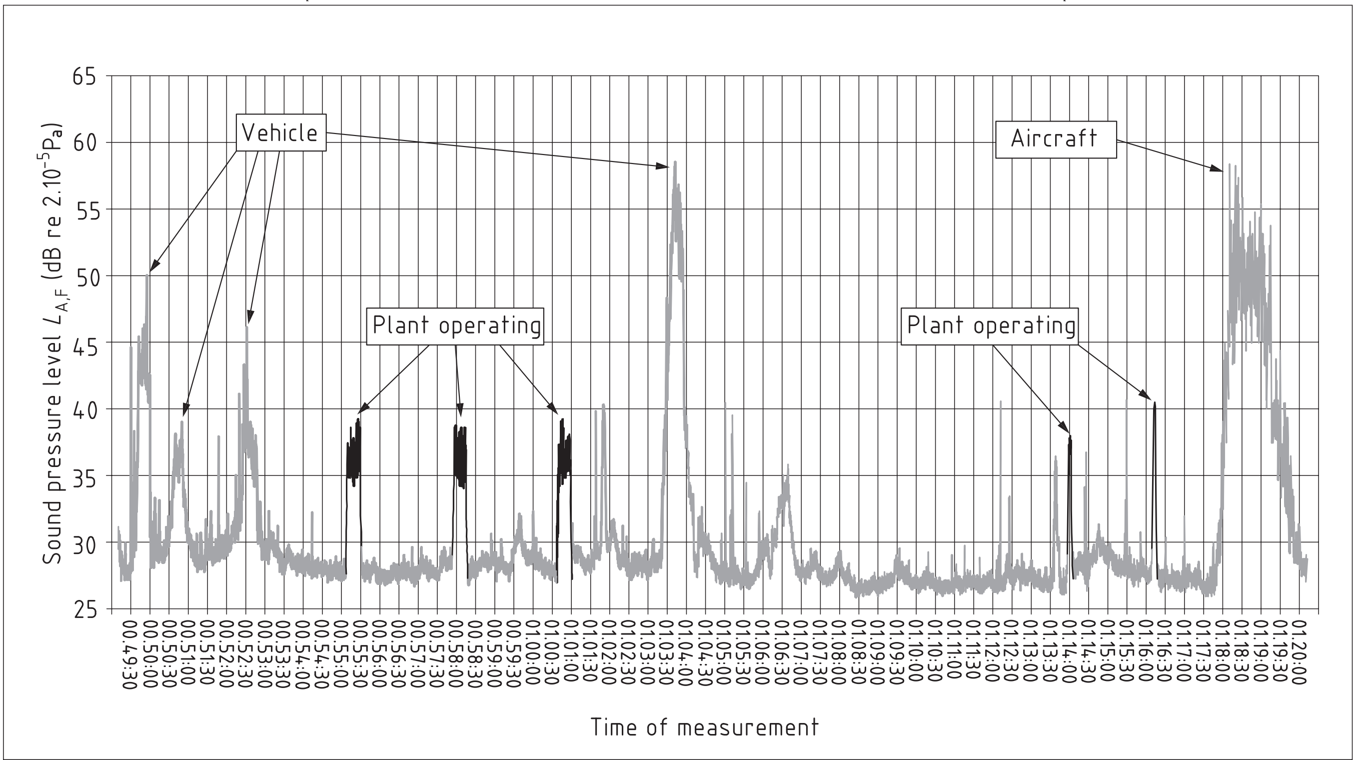
Table A.6 — *Example 6: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	L_{Aeq} = 36 dB	7.3.2	Specific sound source on
Residual sound level	L_{Aeq} = 28 dB	7.3.3	Estimated representative level around the times when source was operating and no vehicles passing, to determine the correction to be made to the measured ambient sound level
Background sound level	$L_{A90(31\ min)}$ = 27 dB	8.1.2	Measured throughout the measurement period and deemed to be representative of the background sound when the source was [A1⟩ not ⟨A1] in operation. Though it should normally be excluded from background measurements, the specific source was judged to be on for a sufficiently short period as not to affect this measurement
Reference time interval of 15 min used for assessment on the basis that the source continues to operate as during the measurement period		7.2	
On time correction (to nearest 0.1 dB as intermediate step in Equation 4 calculation)	10 lg (75.1/900) = -10.8 dB	7.3.15	Total on time of 75.1 s during 15 min period
Specific sound level	$L_{Aeq(15\ min)}$ = [10 lg ($10^{3.6}$ – $10^{2.8}$) – 10.8] dB = 24 dB	7.3.15	Equation 4
Acoustic [A1⟩ character ⟨A1] correction	[A1⟩ 5 dB ⟨A1]	9.2	[A1⟩ +2 dB correction for just perceptible tonality and +3 dB for slight impulsivity outdoors (despite no perceptible acoustically distinguishing characteristics at noise sensitive receptor location i.e. bedroom, indoors) ⟨A1]
Rating level	[A1⟩ (24 + 5) dB = 29 dB ⟨A1]	9.2	
Background sound level	$L_{A90(31\ min)}$ = 27 dB	8.6	
Excess of rating over background sound level	[A1⟩ (29 - 27) dB = 2 dB ⟨A1]	11	

Table A.6 *(continued)*

Results		**Relevant clause**	**Commentary**
Assessment indicates low impact due to plant noise at the receptor		11	The context is a new item of plant at a commercial premises with other plant elsewhere in a residual acoustic environment that, whilst relatively steady, includes regular events of a significantly higher level than that from the plant. At these times the noise-sensitive location is indoors with open windows where residual sound within the dwelling will further mask sound from the plant. [A1) Logarithmically subtracting residual level of 28 dBA from ambient of 36 dBA indicates source produces 35 dBA. BS 8233 indicates that 35 dBA sound level from the plant, equating to an internal level of around 25dBA or lower, with no significant acoustically distinguishing characteristics is suitable for a bedroom. (A1]
Uncertainty of the assessment		10	There is uncertainty in the residual level subtracted from the measured source level, which might account for approximately 1 dB variation in the actual source level. The measurement graph provides confidence that the specific sound level measurements were taken at times when the residual sound level was relatively low and stable. Given the similarity of specific and background sound levels this is not a significant level of uncertainty. The background sound level might be slightly lower on some occasions but is likely to be higher for much of the time depending upon weather conditions.

Figure A.5 — *Sound level outside bedroom window with intermittent plant operation: L_{Aeq} for entire period 40 dB, residual L_{Aeq} when no vehicles passing 28 dB, background L_{A90} 27 dB, ambient L_{Aeq} with plant on 36 dB*



A.6.2 Example 7: Intermittent sound source operating during the day, evening and night, potentially affecting residents in their garden during the late evening, producing a relatively low sound level with slight acoustically distinguishing characteristics

An item of mechanical equipment has been installed at a commercial premises where other plant is also operating elsewhere on site. [A1⟩ This item of mechanical plant operates ⟨A1] intermittently 24 hours a day, producing sound that is identifiable outside the nearest dwelling, particularly when the residual sound falls to lower levels during the late evening. At these more sensitive times the sound contains a tone that is just perceptible outside the dwelling and appears to be slightly impulsive when starting operation. This means that a [A1⟩ character correction ⟨A1] of 2 dB for slight tonality, plus 3 dB for slight impulsivity, is applicable for this assessment.

Figure A.6 shows the sound level time history (measured every 100 ms) on the patio of the neighbouring garden 4 m from the rear of the dwelling for 31 min during the evening, during which time the specific sound source was identifiable on five occasions and the residual acoustic environment included typical variations due to sources such as passing and distant vehicles and an aircraft. The specific sound source is located close to the dwelling, so it was not practicable to take measurements closer to it. The identifiable periods when the source was operating and its constant character reduce the uncertainty in calculating the specific sound level from these measurements.

It is reasonable to assume that the operation of the plant throughout the measurement period is representative of normal operation and that the residual acoustic environment was representative of normal conditions at this time.

The L_{Aeq} for the entire measurement period was 43 dB, falling to a residual sound level of around 31 dB at times when no vehicles were passing and the specific source was not operating. The background sound level L_{A90} was measured as 30 dB for the entire measurement period (the specific source being on for such short periods as to be judged not to affect this measurement) and the ambient L_{Aeq} was measured as 39 dB whilst the specific sound source was operating [A1⟩ and no vehicles were passing ⟨A1].

As Figure A.6 shows, although the residual acoustic environment varies considerably with time, it was relatively steady for the vast majority of the time, particularly when the source was operating, potentially making the associated change in sound level and character due to this industrial/commercial sound source more likely to attract a listener's attention.

The assessment and its results are detailed in Table A.7.

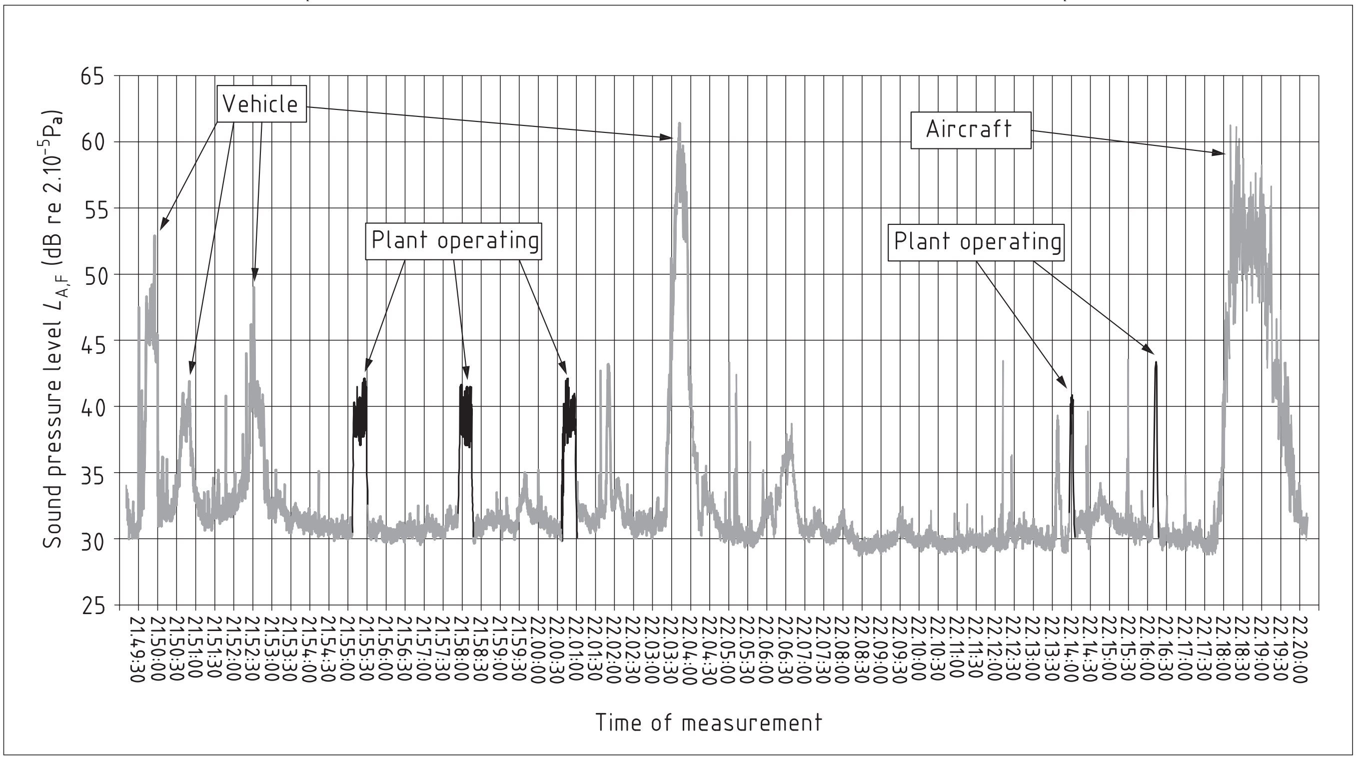
Table A.7 — *Example 7: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	L_{Aeq} = 39 dB	7.3.6	Specific sound source on
Residual sound level	L_{Aeq} = 31 dB	7.3.3	Estimated representative level around the times when source was operating and no vehicles passing, to determine the correction to be made to the measured ambient sound level
Background sound level	$L_{A90(31\ min)}$ = 30 dB	8.1.2	Measured throughout the measurement period and deemed to be representative of the background sound when the source was [A1⟩ not ⟨A1] in operation. Though it should normally be excluded from background measurements, the specific source was judged to be on for a sufficiently short period as not to affect this measurement
Reference period of 1 h used for assessment on the basis that the source continues to operate as during the measurement period		7.2	
On time correction (to nearest 0.1 dB as intermediate step in Equation 4 calculation)	10 lg (93.9/1 860) = -13.0 dB	7.3.15	Total on time of 93.9 s during 31 min measurement period which is representative of operation throughout an hour
Specific sound level	$L_{Aeq(60\ min)}$ = [10 lg ($10^{3.9} - 10^{3.1}$) – 13.0] dB = 25 dB	7.3.15	Equation 4
Acoustic [A1⟩ character ⟨A1] correction	+5 dB	9.2	+2 dB correction for just perceptible tonality and +3 dB for slight impulsivity in garden
Rating level	(25 + 5) dB = 30 dB	9.2	
Background sound level	$L_{A90(31\ min)}$ = 30 dB	8.6	
Excess of rating over background sound level	(30 - 30) dB = 0 dB	11	

Table A.7 *(continued)*

Results		Relevant clause	Commentary
Assessment indicates low impact due to plant noise at the receptor		11	The context is a new item of plant at a commercial premises in a residual acoustic environment that, whilst relatively steady, includes regular events of a significantly higher level than that from the plant. Although the plant noise is somewhat different in character to the residual acoustic environment the rating level of 30 dB is low and will have little impact on residents using their patio during the evening
Uncertainty of the assessment		10	There is uncertainty in the residual level subtracted from the measured source level, which could account for approximately 1 dB variation in the actual source level. The measurement graph provides confidence that the specific sound level measurements were taken at times when the residual sound level was relatively low and stable. Given the similarity of specific and background sound levels this is not a significant level of uncertainty. The background sound level might be slightly lower on some occasions but is likely to be higher for much of the time depending upon weather conditions

Figure A.6 — *Sound level on patio in rear garden with intermittent plant operation: L_{Aeq} for entire period 43 dB, residual L_{Aeq} when no vehicles passing 31 dB, background L_{A90} 30 dB, ambient L_{Aeq} with plant on 39 dB*



A.6.3 Example 8: Intermittent sound source operating at night potentially affecting residents indoors with slight acoustically distinguishing characteristics

An item of mechanical equipment has been installed at a commercial premises where other plant is also operating elsewhere on site. This ⁅A1⟩ item of mechanical ⟨A1⁆ plant operates intermittently 24 hours a day, producing sound that is identifiable outside the nearest dwelling, particularly when the residual sound falls to lower levels when residents might be going to sleep. ⁅A1⟩ Considering context at sensitive times the sound contains a tone that is just perceptible inside the dwelling and appears to be slightly impulsive when operation starts.These characteristics are more clearly perceptible outdoors. This means that a character correction of 4 dB for clearly perceptible tonality outdoors, plus 6 dB for clearly perceptible impulsivity outdoors, is applicable for this assessment. ⟨A1⁆

Figure A.7 shows the sound level time history (measured every 100 ms) 4 m from the nearest dwelling for 31 min at night, during which time the source was identifiable on five occasions and the residual acoustic environment included typical variations due to sources such as passing and distant vehicles, an aircraft and some animal activity. The specific sound source is located close to the dwelling, so it was not practicable to take measurements closer to it. The identifiable periods when the source was operating and its constant character reduce the uncertainty in calculating the specific sound level from these measurements.

It is reasonable to assume that the operation of the plant throughout the measurement period is representative of normal operation and that the residual acoustic environment was representative of normal conditions at this time.

The L_{Aeq} for the entire measurement period was 45 dB, falling to a residual sound level of around 33 dB at times when no vehicles were passing and the specific source was not operating. The background sound level L_{A90} was measured as 32 dB for the entire measurement period (the specific source being on for such short periods as to be judged not to affect this measurement) and the ambient L_{Aeq} was measured as 41 dB whilst the specific sound source was operating [A1) and no vehicles were passing (A1].

The assessment and its results are detailed in Table A.8.

In addition to the rating/background sound level comparison shown in Table A.8, the primary concern is the potential for disturbance of residents who could be sleeping with open bedroom windows. [A1) The change in sound level when the source starts and stops during the night is clearly perceptible outdoors and noticeable indoors. Similarly a tonal component is clearly perceptible outdoors and slightly noticeable in the bedroom. It is appropriate to apply a character correction of 10 dB for the characteristics of the sound outdoors. (A1]

Other guidance, such as BS 8233, might also be applicable in this instance. Though Figure A.7 shows that the residual acoustic environment varies considerably with time, the overall sound level outside the dwelling when the source is operating is slightly greater than 40 dB. In addition to the slight difference between rating and background sound levels, the potential impact due to the absolute sound level also needs to be considered.

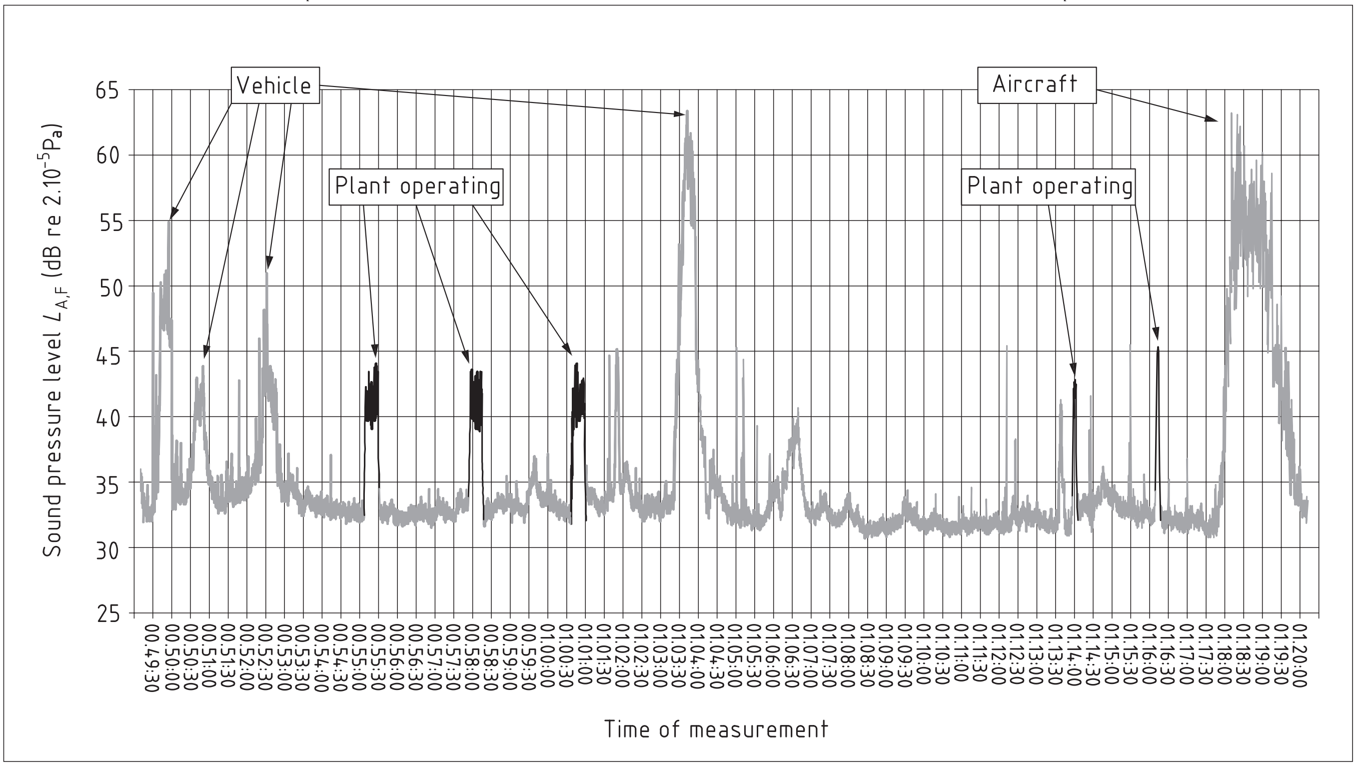
Table A.8 — *Example 8: Assessment*

Results		Relevant clause	Commentary
Measured ambient sound level	L_{Aeq} = 41 dB	7.3.2	Specific sound source on
Residual sound level	L_{Aeq} = 33 dB	7.3.3	Estimated representative level around the times when source was operating and no vehicles passing,to determine the correction to be made to the measured ambient sound level
Background sound level	$L_{A90(31\ min)}$ = 32 dB	8.1.2	Measured throughout the measurement period and deemed to be representative of the background sound when the source was [A1] not [A1] in operation. Though it should normally be excluded from background measurements, the specific source was judged to be on for a sufficiently short period as not to affect this measurement
Reference period of 15 min used for assessment on the basis that the source continues to operate as during the measurement period		7.2	
On time correction (to nearest 0.1 dB as intermediate step in Equation 4 calculation)	10 lg (75.1/900) = -10.8 dB	7.3.15	Total on time of 75.1 s during 15 min period
Specific sound level	$L_{Aeq(15\ min)}$ = (10 lg ($10^{4.1} - 10^{3.3}$) – 10.8) dB = 29 dB	7.3.15	Equation 4
[A1] Acoustic character correction [A1]	[A1] +10 dB [A1]	9.2	[A1] +4 dB correction for clearly perceptible tonality and +6 dB for clearly perceptible impulsivity outdoors. The tonality and impulsivity are slightly perceptible at noise sensitive receptor location i.e. bedroom, indoors. [A1]
Rating level	[A1] (29 + 10) dB = 39 dB [A1]	9.2	
Background sound level	$L_{A90(31\ min)}$ = 32 dB	8.6	
Excess of rating over background sound level	[A1] (39 - 32) dB = 7 dB [A1]	11	

Table A.8 *(continued)*

Results		Relevant clause	Commentary
A1 The excess of 7 dB is greater than 5 dB which, depending upon the context, is likely to be an indication of an adverse impact. It is also possible that the absolute level of slightly over 40 dBA outside the dwelling when the source is operating could adversely affect residents when going to sleep. A1		11	The context is a new item of plant at a commercial premises with other plant elsewhere, in a residual acoustic environment that, whilst relatively steady, includes regular events of a significantly higher level than that from the plant. At these times the noise-sensitive location is indoors with open windows. However, consideration also needs to be given to the cumulative sound level within the bedroom and the slight character of the specific sound. A1 Logarithmically subtracting residual level of 33 dBA from ambient of 41 dBA indicates source produces 40 dBA. BS 8233 indicates that 40 dBA sound level from the plant, equating to an internal level of around 30 dBA or possibly lower, but with some acoustically distinguishing characteristics, may not be suitable for a bedroom. A1
Uncertainty of the assessment		10	There is uncertainty in the residual level subtracted from the measured source level, which might account for approximately 1 dB variation in the actual source level. The measurement graph provides confidence that the specific sound level measurements were taken at times when the residual sound level was relatively low and stable. Although relatively small, the uncertainty means that an adverse impact might be slightly more likely than indicated by the numerical assessment alone. The background sound level might be slightly lower on some occasions, but is likely to be higher for much of the time depending upon weather conditions.

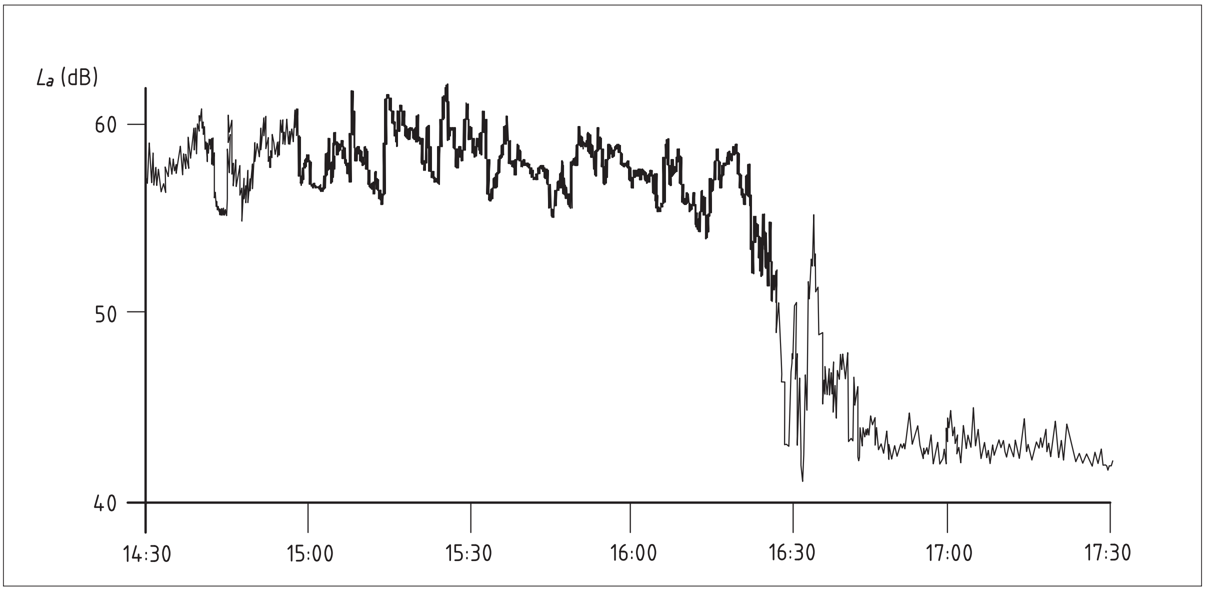
Figure A.7 — *Sound level outside bedroom window with intermittent plant operation: L_{Aeq} for entire period 45 dB, residual L_{Aeq} when no vehicles passing 33 dB, background L_{A90} 32 dB, ambient L_{Aeq} with plant on 41 dB*



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

A scrapyard is sited immediately adjacent to a residential area, producing constant bangs and crashes as well as including tonal features. Figure A.8 shows the sound level time history of a three-hour attended measurement, including 2 h of site noise prior to shut-down at 16:30, and 1 h following the shut-down. The measured ambient sound level prior to shut-down averaged 59 dB [$L_{Aeq(110\ min)}$], and the period immediately after shut-down found a residual sound level of 43 dB [$L_{Aeq(40\ min)}$], and a background sound level of 41 dB [$L_{A90(40\ min)}$].

Figure A.8 — *Sound level variation with time*



A subjective assessment of the impulsivity was considered inadequate to establish an appropriate rating penalty, so the reference method was used. The first half-hour period was assessed, which found regular impulses, the most prominent of which had a level change of 26.5 dB and an onset rate of [A1⟩ 212 dB/s ⟨A1]. This event had a calculated prominence *P* of 8.6, resulting in an adjustment *KI* of 8.7 dB. This was rounded to a rating penalty of 9 dB.

In addition to the impulsivity, there were also numerous tonal features, most notably the use of an angle grinder for 15 min within the 2 h of site activity. This source was prominently tonal, and met the one-third octave criteria for tonality. As this source was not constantly present, a rating penalty of 4 dB was considered appropriate.

The assessment and its results are detailed in Table A.9.

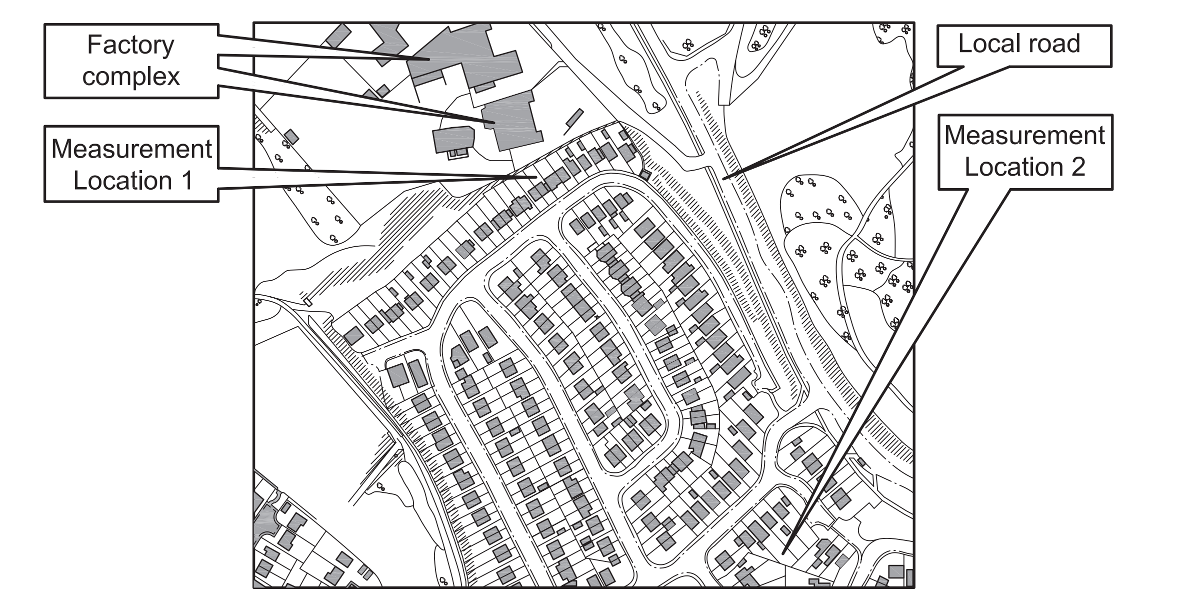
Table A.9 — *Example 9: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	$L_{\text{Aeq(110 min)}}$ = 59 dB	7.3.2	Specific sound on
Residual sound level	$L_{\text{Aeq(40 min)}}$ = 43 dB	7.3.3	Specific sound off to determine the correction to be made to the measured ambient sound level
Background sound level	$L_{\text{A90(40 min)}}$ = 41 dB	8.3	The background sound level was measured immediately after shut-down and was considered to be representative
Assessment made during the daytime, so the reference time interval is 1 h		7.2	
Specific sound level corrected	$L_{\text{Aeq(60 min)}}$ = 59 dB	7.3.4	
Acoustic [A1⟩ character ⟨A1] correction	(9 +4) dB = 13 dB	9.2	Additive penalties for both impulsivity and tonality
Rating level	(59 +13) dB = 72 dB	9.2	
Background sound level	$L_{\text{A90(40 min)}}$ = 41 dB	8	
Excess of rating level over background sound level	(72 – 41) dB = 31 dB	11	
Assessment indicates a likelihood of a significant adverse impact		11	
Uncertainty of the assessment		10	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

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

The noise from a factory is the cause of complaint from the local population. The factory uses large furnaces that run continuously, and the factory cannot be shut down to enable the measurement of the residual and background sound levels. It was decided to use a surrogate measurement location to obtain these levels. The measurement locations are presented as Figure A.9.

Figure A.9 — *Measurement locations*



The acoustic environment at Measurement Location 1, which is the assessment location, was heavily dominated by factory noise, with some traffic on a local road also audible. This location was used to assess the ambient sound level. Measurement Location 2 was not affected by factory noise due to the greater propagation distance and the barrier effect of other housing. This location was used to measure the residual and background sound levels. Both measurement locations were the same distance from the same road, had a similar amount of screening to the road, and the road gradient and surface roughness did not change. The acoustic environment was considered to be equivalent at both locations, other than for the presence of the factory. Both measurement locations were free-field.

Unattended measurement was performed concurrently at both measurement locations using synchronized sound level meters over a period of one week. This ensured that the weather conditions were identical at both monitoring locations. A logging weather station was deployed at Measurement Location 2 to allow for periods of adverse weather to be discounted.

The sound from the factory included a flame roar from the furnaces, but did not contain impulsive sounds or tonal features. A subjective assessment of the acoustic features considered an overall 3 dB rating penalty to be appropriate.

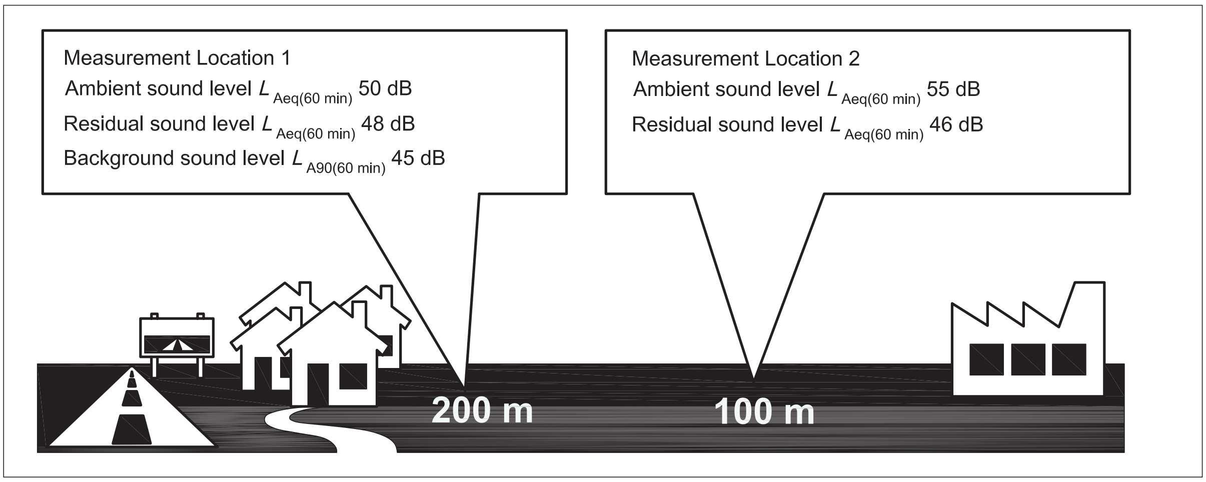
The uncertainty of the assessment was minimized by using concurrent measurement, by avoiding adverse measurement conditions, and by using a longer period of measurement to ensure that the measurement was representative.

A.9 Example 11: Propagation corrections

A small factory is 200 m from a residential area across open fields. On the other side of the residential area is a busy road. The acoustic environment at the receptor is equally dominated by sound from the road and sound from the factory. The sound from the factory is generally unlikely to attract attention, but includes a faint mid-frequency tone from an air handling unit.

Initial monitoring at the receptor (Measurement Location 1) found a consistent measured free-field sound level of $L_{Aeq(60\ min)}$ 50 dB when the factory was operating, and a residual sound level of $L_{Aeq(60\ min)}$ 48 dB and a background sound level of [A1] $L_{A90(60\ min)}$ [/A1] 45 dB during a voluntary shut-down. As the difference between the ambient and residual sound levels was less than 3 dB, a second period of measurement was undertaken at Measurement Location 2, in free-field conditions in open grassland, and on a direct line between the factory and the receptor. These locations are presented in Figure A.10.

Figure A.10 — *Measurement locations*



At Measurement Location 2, the road noise was only faintly audible, and the acoustic environment was dominated by the factory, with a prominent tonal feature produced by the air handling system. At this location the ambient sound level was $L_{Aeq(60\ min)}$ 55 dB, and the residual sound level was found to be $L_{Aeq(60\ min)}$ 46 dB. Subtracting the residual sound level from the ambient sound level resulted in a specific sound level of $L_{Aeq(60\ min)}$ 54.4 dB at this location.

The specific sound level at Measurement Location 2 was then corrected to account for the greater distance to the receptor at Measurement Location 1. Spherical propagation was accounted for using formula A.1.

$$L_2 = L_1 - 20\lg)\left(\frac{R_2}{R_1}\right) \quad \text{(A.1)}$$

where:

R_2 = 200 m

R_1 = 100 m

L_1 = 54.4 dB

This resulted in a predicted level of 48.4 dB at Measurement Location 1 (L_2 for the purposes of the formula). This level was further corrected by -0.6 dB for the effects of air absorption over the additional 100 m distance, and -1.8 dB for the effects of ground absorption (at a mean propagation height of 1 m, and using a ground absorption factor of 1). This resulted in an overall predicted specific sound level of 46 $dB_{(LAeq,\ 60\ min)}$ at the receptor. (See calculation method in ISO 9613-2.)

The assessment and results are detailed in Table A.10.

Table A.10 — *Example 11: Assessment*

Results		**Relevant clause**	**Commentary**
Measured ambient sound level	$L_{\text{Aeq(60 min)}}$ = 55 dB	7.3.6	Specific sound on, measured at Measurement Location 2
Residual sound level	$L_{\text{Aeq(60 min)}}$ = 46 dB	7.3.6	Specific sound off, measured at Measurement Location 2
Background sound level	$L_{\text{A90(60 min)}}$ = 45 dB	8.3	The background sound was measured at Measurement Location 1
Assessment made during the daytime, so the reference time interval is 1 h		7.2	
Specific sound level at Measurement Location 2	$L_{\text{Aeq(60 min)}}$ = 54.4 dB	7.3.4	
Specific sound level calculated at Measurement Location 1	$L_{\text{Aeq(60 min)}}$ = 46 dB	7.3.6	Accounting for spherical propagation, air absorption and ground absorption.
Acoustic feature correction	+2 dB	9.2	A mild tone was subjectively audible at the receptor
Rating level	(46 +2) dB = 48 dB	9.2	
Background sound level	$L_{\text{A90(60 min)}}$ = 45 dB	8	
Excess of rating over background sound level	(48 – 45) dB = 3 dB	11	
After taking context into account, assessment indicates there is unlikely to be an adverse impact		11	The dominant road noise at the receptor reduces the likelihood of an adverse impact from the factory

The uncertainty was minimized by measuring in still wind conditions and over a representative monitoring period.

The uncertainty associated with measuring at an intermediate location (Measurement Location 2) is lower than the uncertainty associated with measuring sound power levels at the factory which may not accurately account for directionality or planar sources.

The remaining uncertainty associated with the propagation calculations means that an adverse impact could still be present when the wind is blowing from the source to the receptor.

Annex B (informative) Consideration of uncertainty and good practice for reducing uncertainty

B.1 General

Because this standard is not intended to provide a single numerical value against which the significance of a sound source can be determined, consideration needs to be given to the uncertainties involved in sound level measurements and subsequent assessment of data, together with the potential effects of such uncertainties on the outcome of the assessment. It is not appropriate to numerically estimate the uncertainty and simply make an allowance for this value in any assessment. Instead, an appropriate consideration of uncertainty based on professional judgement can enable an informed decision to be made regarding the likely significance of the impact of sound, whilst considering the range of likely levels and context of the assessment.

There is inevitably uncertainty in measured sound levels, leading to uncertainty in calculated numerical results. This is particularly relevant where the ambient sound level with the specific source operating is similar to the residual sound level and also where the residual sound level varies notably during measurement periods. Some components of the measurement uncertainty, such as those due to instrumentation, can reasonably be quantified, although this is not necessarily the case for other components, especially regarding meteorological conditions. Any attempt at the complete quantification of uncertainty becomes more complex for calculated levels which are a logarithmic subtraction of one measured level from another.

Guidance produced by the University of Salford [3] provides information regarding the minimization and quantification of uncertainty in sound levels being measured at the time of measurement. Further uncertainty is recognized by temporal variation in the residual sound level, possibly during the measurement process and particularly under different meteorological conditions. There is also likely to be uncertainty and/or variability in the sound level produced by the source being assessed; or in available data if the source is yet to be installed/operated.

As the residual or specific sound level changes its character may also change. This should also be considered as part of the assessment. For example, the residual sound level might be relatively steady when the wind direction is from a motorway, but could vary to a much greater extent and fall to somewhat lower levels when the wind is in the opposite direction.

Conversely, there might be relatively little variation in a residual sound level that is strongly influenced by nearby plant that is unrelated to the source under investigation. Certain plant and machinery can otherwise produce higher sound levels at times of higher load which might be seasonal dependant or related to other demands. These are relevant factors to consider.

B.2 Good practice for reducing uncertainty

COMMENTARY ON ***B.2***

This sub-clause draws on Craven and Kerry 2007 [4].

B.2.1 General

All measurement results have an associated element of doubt about their true value. In general terms, this is referred to as measurement uncertainty, and is attributed in part to unknown factors influencing the measurement, or an inability to determine the influence of a known quantity with a better accuracy. In the case of environmental sound measurements, it is usually factors influencing the source and propagation path rather than instrumentation shortfalls that cause most concern due to measurement uncertainty. A knowledge of the source and magnitude of these factors assists with interpretation of the results, indicating differences which might not be significant, and identifying areas where greater attention to detail can improve assessments.

B.2.2 Good practice guidelines: sources of sound

B.2.1.1 Spectral content (broadband and tonal sound)

- Establish whether standing waves/interference patterns are present by considering the nature of the source and the influence of any nearby sound reflecting surfaces. This can be carried out subjectively by listening in several places around the measurement location, or by measuring any change in sound pressure levels with a sound level meter at different locations in the immediate locality when traversing the measurement location.
- If standing waves are present and cannot be avoided, take a spatial average, either by measuring at several fixed locations, or by slowly moving the microphone around the measurement location, whilst continually measuring sound level.
- Gauge whether uncertainty could be significant when measuring sound at low and high frequency regions, e.g. below approximately 125 Hz or above 4 kHz respectively.

B.2.2.2 Point, line and area sources/the near and far fields

- Investigate all sound sources to understand their propagation characteristics and how these might influence the choice of the measurement location(s).
- At large distances from a source in a homogeneous, non-dissipative atmosphere in the absence of a reflective plane, the sound pressure varies inversely with the distance from the source. If the dimension of the source is large relative to the wavelength of sound it radiates, or if the distance from the centre of the source is small relative to the overall source dimensions, there is a region where pressure maxima and minima might occur and consequently sound pressure does not vary inversely with distance.

B.2.2.3 Source configuration and operation

- Source operating parameters that could have a significant effect on measurement results should be identified and recorded.
- If necessary, measure under different operational conditions, the type and number of which will depend upon the nature of the task/reason for measurement, for example, it might be appropriate to measure under the following conditions:
  - sound source under normal load;
  - sound source under full load; and
  - sound source under no load (idling).

B.2.2.4 State of repair and maintenance

- Determine and record the state of repair of the sound source(s) and features that might afford control of sound.

- Where possible, carry out additional checks to determine the likely variation in level before and after maintenance.

B.2.2.5 Source height

- Anticipate greater uncertainty when measuring sound from elevated sources. Repeat measurements under different propagation conditions, if necessary.

B.2.2.6 Movement of the sound source

- Determine and log the movement and number of source(s) during the measurement. If the movement follows a routine, measure representative sound levels for one or more complete cycles.

B.2.2.7 Weather

- Determine the likely effect of changes in the prevailing weather conditions on the sound source having regard to 6.3 and 6.4.
- Ensure that the sound source is operating under conditions relevant to the purpose of the survey.
- Record and report the prevailing conditions at the time of measurement.

B.2.3 Good practice guidelines: transmission path

B.2.3.1 General

- Use weather forecasts when planning measurement sessions.
- Record meteorological conditions at appropriate times across the duration of the measurement and report.
- Unless circumstances appropriate to the assessment dictate otherwise, it is preferable to measure during meteorological conditions favourable to propagation. These conditions are for downwind propagation, namely when the wind direction is within an angle of ±45° of the direction connecting the centre of the dominant source and the centre of the specified receiver region and with the wind blowing from source to receiver [ISO 9613-2, ANSI/ASA S12.18].
- Measurements should be avoided when atmospheric conditions give rise to temperature inversions or complex lapse/inversion situations which can give rise to anomalous sound propagation unless circumstances appropriate to the assessment dictate otherwise

B.2.3.2 Ground effects

- Avoid sound measurement during precipitation. (When carrying out long-term measurements it might not be possible or even desirable to avoid such periods. In such cases an accurate log of the weather assists with the analysis.) Measurement when the ground is wet or snow covered is highly discouraged, but if it is necessary to obtain data under these situations, carefully describe the conditions.
- In all cases, fully describe the ground surface between the sound source and measurement location, noting features which may influence the acoustic impedance. For grazing angles less than approximately 20°, the following general descriptions may be used as a guide for characterizing the ground type (in the absence of measured acoustic impedance data):
  - hard ground: open water, asphalt, concrete pavements or other ground surfaces having low porosity that are highly reflective; and
  - soft ground: areas covered with grass, vegetation and other porous types of ground suitable for the growth of vegetation, e.g. farming land - new fallen snow is more absorptive at low

frequency than grass covered ground, but avoid measurements above snow covered ground unless operation of the source is intimately associated with this condition.

At grazing angles greater than around 20°, which can occur when the sound source is close to the receiver and/or if the sound source is elevated, soft ground can become a good reflector and may need to be considered as hard ground.

- Consider taking a spatial average when measuring tonal sound close to an acoustically hard surface.
- Estimate source and receiver heights/distance and report with measurement results.

B.2.3.3 Barriers

- Have due regard for effect of seasonal changes on foliage.

B.2.4 Good practice guidelines: receiver

B.2.4.1 General

- Criteria for selection of representative background sound measurement location, as justified by the purpose of the measurement.
- Exact microphone location should be reported in the measurement record. To enable correct interpretation and repetition of the measurement, the record should include:
  - justification of selection of measurement location;
  - diagrams showing distances to significant reflecting surfaces (including height above ground level); and
  - orientation of microphone.
- The microphone height and reason for choosing that height should be recorded.
- Note distance from facade and features of facade.
- Specify any assumed correction applied before stating final result.
- If possible, do not measure near any reflecting object, other than the ground plane.
- Note location, type and characteristics of any unavoidable objects.
- Where possible, orientate the microphone relative to the dominant sound source according to the instrument manufacturer's advice.

B.2.4.2 Use of equipment

- Check standard in use for appropriate microphone response and check microphone in use conforms to the applicable standard.
- Be aware of the type of microphone in use or the effect of any mechanical or electrical devices that can modify the effective response.
- Ensure that the microphone and sound measuring system responses are compatible.
- Ensure that the whole measurement chain, including the field calibrator (see **5.1.2**) meets the required degree of precision.
- Report the type of sound measuring system used with the measurement results together with details of all other instrumentation used.
- Conduct all measurements using sound level meters and field calibrators whose conformance and calibration have been checked periodically against national standards (guidance can be obtained from UKAS publication, LAB 23 [5], or the relevant measurement standard in use).

- Calibrators should be checked preferably at least once per year and sound measuring systems every two years, or at more frequent intervals depending upon usage and conditions (harsh environments, etc.). All instrumentation should be re-calibrated if damaged and after repair.
- Sound level meters, particularly the microphone and field calibrators should be stored under environmental conditions in accordance with manufacturers' instructions).
- Investigate anomalous measurement results to ensure early detection of faults.
- Calibrate sound measuring systems:
  - before and after measurements (and during, if long-term or there are changes in external environment, e.g. change of power supply, changes in atmospheric pressure);
  - on site, i.e. under the same environmental conditions as the measurement taken, in the same configuration as that used for the measurement (e.g. with an extension cable in place);
  - whilst isolated from vibrations, i.e. resting on a resilient (rubber) mat and in a suitable low level sound environment; and
  - to compensate for local variation in environmental conditions and confirm correct operation of the sound level meter.
- The results of calibration should be recorded and reported with the measurement results.

B.2.4.3 Long duration surveys

- When measuring using long-term installations, the measurement system should be calibrated regularly. Logging results provides data from which calibration intervals can be properly assessed.
- Choose the most appropriate microphone for each situation.
- Place the microphone at the correct orientation to the major sound sources.

B.2.4.4 Short duration surveys

- Avoid the use of long microphone extension cables whenever possible.
- Carry out field calibrations with all cables in place.
- Regularly calibrate the whole measurement system when using long cables.
- Use balanced cables.

B.2.4.5 Sound measuring system settings

- Take measurements using the time and frequency weighting specified by the relevant standard, guideline or procedure.
- Where no weightings are specified, it is normally preferable to measure using the fast time constant and the A-weighting frequency network, unless significant low- or-high frequency energy is present.
- Report all results [A1⟩ with reference to ⟨A1] the time and frequency weighting used during measurement.

B.2.4.6 Data retrieval

- Use digital transfer methods wherever possible, but double check data when transferring manually.

B.2.4.7 General practice

- Select measurement locations to minimize the influence on the measurement result of all factors other than the subject of the measurement.
- Report and justify the criteria used to select each measurement location.
- To enable repeatable, and therefore comparable, measurements document the microphone locations (report GPS coordinates if available), and include a description of all relevant factors such as distances to all significant reflecting surfaces and other features.
- View measurement results in the context of the location where they were taken. Measurements taken at different locations should not automatically be seen as directly comparable.
- When assessing community noise complaints, it is useful to measure at a number of locations around the noise source to build up an understanding of the acoustic environment.
- Where it is necessary to measure at an alternative location, consider the distance to each major background sound source and the topography between the measurement position and each major background sound source;
- There is no recognized method for the choice of alternative measurement locations as circumstances are often unique to the situation. The best approach is one based upon reasoned decision-making.
- If the time and resources are available, make repeated measurement at a number of measurement locations in order to determine the most representative sound level.
- Justify the choice of background measurement location in the survey report.
- Use this check list or a custom version before setting out the measurement plan or commencing measurements.

NOTE Further information on good practice to reduce uncertainty in environmental sound measurements can be found in the ANC Green Book [6].

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

The test for the presence of a prominent, discrete-frequency spectral component (tone) typically compares 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. For a prominent, discrete tone to be identified as present, the time-averaged sound pressure level in the one-third-octave band of interest is required to exceed the time-averaged sound pressure levels of both adjacent one-third-octave bands by some constant level difference.

The level differences between adjacent one-third-octave bands that identify a tone are:

- 15 dB in the low-frequency one-third-octave bands (25 Hz to 125 Hz);
- 8 dB in middle-frequency one-third-octave bands (160 Hz to 400 Hz);
- 5 dB in high-frequency one-third-octave bands (500 Hz to 10 000 Hz).

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

D.1 Introduction

If the presence of audible tones is in dispute, the measurement procedure in this annex can be used to verify their presence. Based on the prominence of the tones this procedure also provides recommended level adjustments. The aim of the reference method is to assess the prominence of tones in the same way as listeners do on average. The method is based on the psychoacoustic concept of critical bands, which are defined so that sound outside a critical band does not contribute significantly to the audibility of tones inside that critical band.

The method includes procedures for steady and varying tones, narrow-band sound, low-frequency tones, and the result is a graduated 0 dB to 6 dB adjustment. It is known as the Joint Nordic Method 2 and is to be found in ISO 1996-2.

D.2 Objective method

D.2.1 General

The method has three steps:

a) narrow-band frequency analysis [preferably FFT analysis];

b) determination of the average sound pressure level of the tone(s) and of the masking sound within the critical band around the tone(s); and

c) calculation of the tonal audibility, ΔL_{ta}, and the adjustment, K_f.

D.2.2 Frequency analysis

A narrow-band A-weighted spectrum is measured by linear averaging for at least 1 min (“long-term average”).

The effective analysis bandwidth needs to be less than 5% of the bandwidth of the critical bands with tonal components. The widths of the critical bands are shown in Table D.1.

The measuring set-up, including the frequency analyser, should be calibrated in dB re 20 µPa, and the Hanning weighting used as the window function.

NOTE 1 With the recommended Hanning time window the effective analysis bandwidth (or the effective sound bandwidth) is 1.5 times the frequency resolution. The frequency resolution is the distance between the lines in the spectrum.

NOTE 2 With an effective analysis bandwidth of 5% of a critical band, just audible tones normally appear as local maxima of at least 8 dB above the surrounding masking sound in the averaged spectra.

NOTE 3 In rare cases of a complex tone with many closely spaced tone components, a finer resolution might be needed to determine the level of the masking sound correctly.

NOTE 4 If the frequency of audible tones in the spectrum varies by more than 10% of the frequency range of the critical band within the averaging time, it might be necessary to subdivide the long-term average into a number of shorter-term averages.

D.2.3 Determination of sound pressure levels Sound pressure level of tones, L_{pt}

The tones may be determined from the narrow-band frequency spectrum by visual inspection. The sound pressure levels of the tones are determined from the spectrum.

All local maxima with a 3 dB bandwidth smaller than 10% of the bandwidth of the actual critical band are regarded as a tone.

The levels, $L_{pti,}$ of all tones, i, in the same critical band are added on an energy basis to give the total tone level for that band, L_{pt}

$$L_{pt} = 10\lg \sum 10^{L_{pt}/10} \qquad \text{(D.1)}$$

NOTE 1 If a “tone” is a narrow band of sound or if the frequency of a tone varies or if the tone frequency does not coincide with the frequency of a spectral line, the tone appears as several lines in the averaged spectrum. In such cases the tone level, $L_{pti,}$ is the energy sum of all lines, with levels within 6 dB of the local maximum level and corrected for the influence of the applied window function (for Hanning weighting this is the energy sum of the lines minus 1.8 dB).

NOTE 2 In cases where tones appear at low frequencies, it is advisable to investigate if the total tone level is above the hearing threshold (BS EN ISO 389-7). If the total tone level in a critical band is below the hearing threshold, this critical band is to be disregarded in the assessment of tonal audibility.

D.2.4 Bandwidth and centre frequency of critical bands

The widths of the critical bands are shown in Table D.1.

The critical band is positioned with its centre frequency, f_c at the tone frequency. When a number of tones are present in the range of a critical band, the critical band is positioned symmetrically around the most significant tones in such a way that the difference between the total tone level, $L_{pt,}$ and the level of the masking sound, $L_{pn,}$ is maximized.

Table D.1 — *Widths of critical bands*

Centre frequency, f_c	**50 Hz to 500 Hz**	**Above 500 Hz**
Bandwidth	100 Hz	20% of f_c

NOTE 1 For the definition of the centre frequency of a critical band, only tones with levels 10 dB or less below the level of the tone with the maximum level should be regarded as significant.

NOTE 2 The centre frequency of the critical bands, f_c, might vary continuously over the frequency range of interest. The lowest critical band is 0 Hz to 100 Hz.

D.2.5 Sound pressure level of the masking sound within a critical band, L_{pn}

The average sound level in a critical band, $L_{pn,avg,}$ may be determined by visually averaging the levels of the "noise lines" in the narrow-band frequency spectrum in a range of approximately ±0.5 to ±1 critical band from the centre frequency, f_c. The "noise lines" are found by disregarding all maxima in the spectrum resulting from tones and their possible side bands in that range.

The total sound pressure level of the masking sound, L_{pn} is calculated from the average sound level within the critical band, $L_{pn,avg,}$ as follows:

$$L_{pn} = L_{pn,avg} + 10\lg \frac{B_{crit}}{B_{eff}} \qquad (D.2)$$

where:

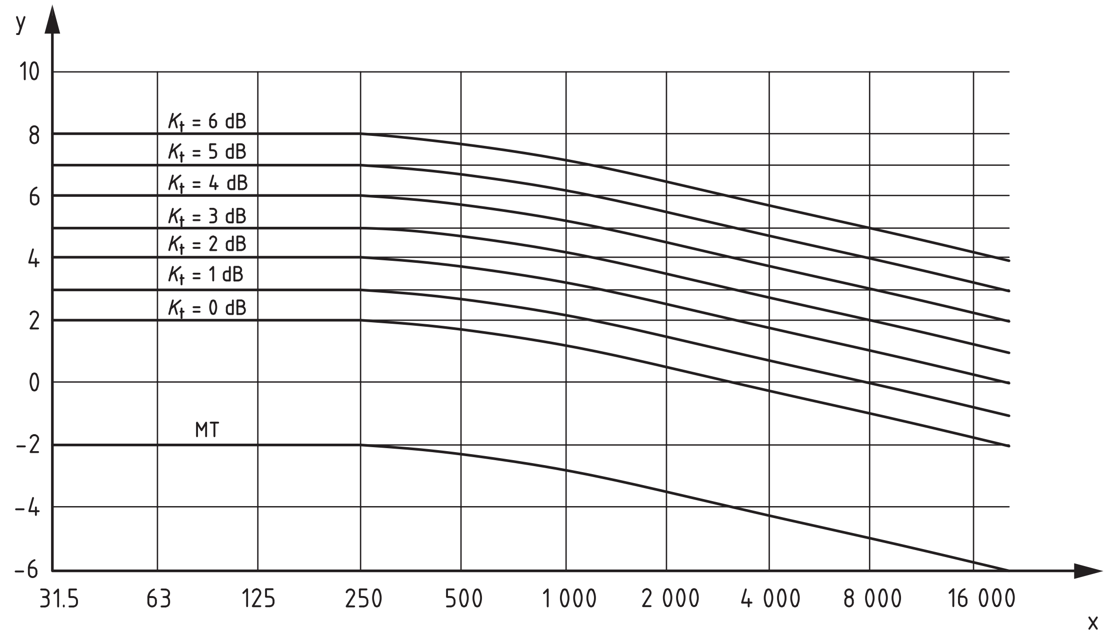
B_{crit} = critical bandwidth, Hz;

B_{eff} = effective analysis bandwidth, Hz.

D.2.6 Calculation of the tonal audibility, ΔL_{ta}, and the adjustment, K_T

The tonal audibility, $\Delta L_{ta,}$ is expressed in dB above the masking threshold, MT. The adjustment, K_T, is the value to be added to the value of L_{Aeq} for a time interval to give the tone-corrected rating level for that interval. From the difference between tone level and sound level in a critical band, $L_{pt} - L_{pn}$, both ΔL_{ta} and K_T may be determined by means of the graph in Figure D.1. A given centre frequency (Hz), f_c, of the critical band and a given level difference $L_{pt} - L_{pn}$ determine a point on the graph. ΔL_{ta} is determined as the difference between $L_{pt} - L_{pn}$ and the masking threshold shown in the figure. K is read by interpolating between the lines marked with different values of K_T in the figure. Alternatively, ΔL_{ta} can be calculated by means of the equation D.3, and K_T can be calculated by means of equation D.3.

Figure D.1 — *Determination of tonal audibility, ΔL_{ta}, and adjustment, K_T*



Key

x Centre frequency of the critical band (Hz) y $L_{pt} - L_{pn}$ (dB)

NOTE L_{pt} is the total sound pressure level of the tones in the critical band, and L_{pn} is the total sound pressure level of the masking noise in the critical band.

The adjustment, K_T, in dB is determined by Equation D.3:

$$\Delta L_{ta} = L_{pt} - L_{pn} + 2 + \lg\left[1 + \left(\frac{f_c}{502}\right)^{2,5}\right] \quad \text{(D.3)}$$

where:

L_{pt} is the total sound pressure level of the tones in the critical band;

L_{pn} is the total sound pressure level of the masking sound in the critical band; and

f_c is the centre frequency in Hz of the critical band.

The adjustment is as follows:

10 dB < ΔL_{ta}:	K_T = 6 dB
4 dB ≤ ΔL_{ta} ≤ 10 dB:	$K_T = \Delta L_{ta}$ -4 dB
ΔL_{ta} < 4 dB:	K_T = 0 dB

NOTE K_T is not restricted to integer values.

When several tones (or groups of tones) occur simultaneously in different critical bands, separate assessments are made for each of these bands. The critical band containing the most dominant tone(s) (i.e. giving the highest value of ΔL_{ta}) is decisive for the value of ΔL_{ta} and the adjustment, K_T.

D.2.7 Documentation

Documentation for the analysis should contain the following information.

a) For the analysis:

1) number of averaged spectra, measurement time period and effective analysis bandwidth;

2) time window (e.g. Hanning), time weighting (Lin) and frequency weighting (A); and

3) one typical spectrum (at least) with an indication of the position of the critical band and the average sound level in that band.

b) For the calculations in the decisive critical band:

1) a statement of whether the results were obtained by visual inspection or by automatic calculation;

2) the frequency limits of the critical band and the range for the visual averaging or linear regression;

3) the frequencies and levels of the tones and the total tone level (L_{pti} and L_{pt} in dB re 20 μPa);

4) the masking sound level in the critical band (L_{pn} in dB re 20 μPa);

5) the audibility of the tones (ΔL_{ta} in dB above the masking threshold); and

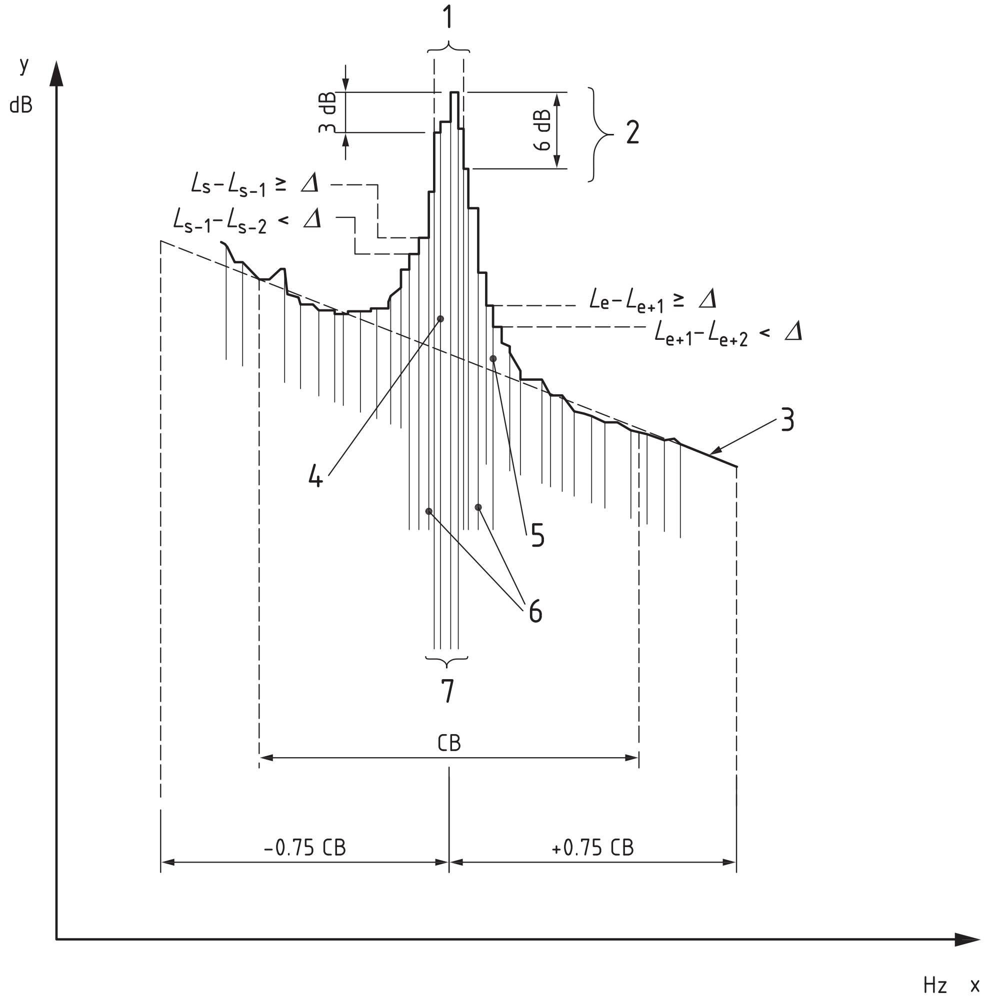
6) the size of the adjustment (K_T in dB).

Tones in other critical bands that might cause an adjustment should be mentioned by their frequencies.

D.2.8 Detailed definitions of tone and masking sound levels

With a view to computer implementations of the method, more comprehensive definitions of tones and sound are given in Figure D.2.

Figure D.2 — *Definitions of tones, noise, and noise pause (neither tone nor noise)*



Key

1	Tone when the 3 dB bandwidth is less than 10% of the critical band	5	Noise-pause end
2	Tonal energy	6	Neither tone nor noise
3	Linear regression line of the noise level	7	Tone
4	Noise-pause start	CB	Critical band

NOTE Δ is the tone-seek criterion and is normally chosen as 1 dB.

NOTE The technician performing the analysis has the final responsibility for the correctness of the results. It is therefore important that software implementations make it possible to visually inspect the results. At least a spectrum is needed with the lines defined as tones indicated together with the corresponding critical bands and regression lines. Furthermore, separate colouring of spectrum lines characterized as noise, noise pause, and tones would be helpful.

D.2.9 Noise pauses

Noise pauses are local maxima with a probability of a tone. The noise pauses are defined and found according to the following principle.

The start of a noise pause is found on the positive slope of a local maximum as the line, *s*, where the following conditions are met:

$$L_s - L_{s-1} \geq \Delta \text{ dB and } L_{s-1} - L_{s-2} < \Delta \text{ dB}$$

where:

L_s is the level of line number s

L_{s-1} is the level of line number s – 1, etc.

Δ is the tone-seek criterion (normally chosen as 1 dB).

NOTE For normal and smooth spectra a tone-seek criterion of Δ = 1 dB works without problems. For irregular spectra (e.g. spectra with short averaging time, values of up to 3 dB or 4 dB might give better results. This parameter should be user-defined in software implementations of the method.

The end of a noise pause is defined on the negative slope of a local maximum as the line, *e*, where the following conditions are met:

$L_e - L_{e+1} \geq \Delta$ dB and $L_{e+1} - L_{e+2} < \Delta$ dB

A preliminary noise pause interval is defined as all the lines *s* to *e*, including both.

The search for the next noise pause starts at line number *e* + 1.

A noise pause can only contain one noise pause start and one noise pause end. A procedure similar to this is performed by investigating the lines in the spectrum from high towards lower frequencies.

Final noise pause intervals: lines defined as preliminary noise pause in both the forward and backward procedure are included in the final noise pause intervals.

D.2.10 Tones

The tones are to be found within noise pauses. A tone can exist when the level of any line in the noise pause is 6 dB or more above the levels of line numbers *s* – 1 and *e* + 1.

Tones includes single tones as well as narrow bands of sound. The bandwidth of the detected peak in the spectrum is defined as the 3 dB bandwidth relative to the maximum line in the noise pause.

When the 3 dB bandwidth is smaller than 10% of the critical bandwidth, all lines with levels within 6 dB of the maximum level are classified as tones. The tone frequency is defined as the frequency of the line with the maximum level in the noise pause.

NOTE 1 When this 3 dB bandwidth is larger than 10% of the critical bandwidth, the lines are regarded as neither tones nor narrow-band sound. No adjustment is given for this phenomenon, unless it is caused by a tone with varying frequency, then a shorter averaging time is necessary.

NOTE 2 Tones with varying frequency might appear as broad maxima in the long-term average spectrum. The width of these maxima depends on the range of the frequency variation of the tone and the averaging time. When the frequency of a tone varies more than 10% of the width of the critical band during the averaging period, the 10% bandwidth criterion is overruled, and all lines within the broad maximum of the tone are classified as tones or a shorter averaging time is used.

D.2.11 Masking sound

All lines not characterized as noise pauses are defined as masking sound, designated “noise lines”.

The masking sound level within a critical band is defined by making a first order linear regression through all lines defined as noise. The range of the regression should usually be chosen as ±0.75 critical bandwidth around the centre frequency of the critical band.

NOTE For irregular spectra or for spectra with broad tonal maxima, the range of the linear regression may be extended to ±1 or 2 critical bands. This might bring the regression line in better correlation with the general shape of the noise floor. It is recommended for the range of the regression analysis to be user-defined in software implementation.

To each spectral line within the actual critical band a sound level, L_n, is assigned as predicted by the regression line. The total masking sound level, L_{pn}, in the critical band is determined as the sum on an energy basis of the assigned levels, L_n, for all lines in the critical band with correction for the applied window function.

$$L_{pn} = 10\lg \sum 10^{L_n/10} \text{ db} + 10\lg \Delta f / B_{eff} \quad \text{(D.4)}$$

where:

Δf = Frequency resolution, Hz;

B_{eff} = Effective analysis bandwidth, Hz.

D.3 Examples

D.3.1 General

The examples in this sub-clause have been analysed with an automatic procedure as follows:

Number of spectra: 350;

Measurement time: 2 min.

D.3.2 Example 1

Critical band: 3.6 kHz – 4.4 kHz;

Tones: 4 kHz, 46.7 dB

Tonal level: L_{pt} = 46.7 dB

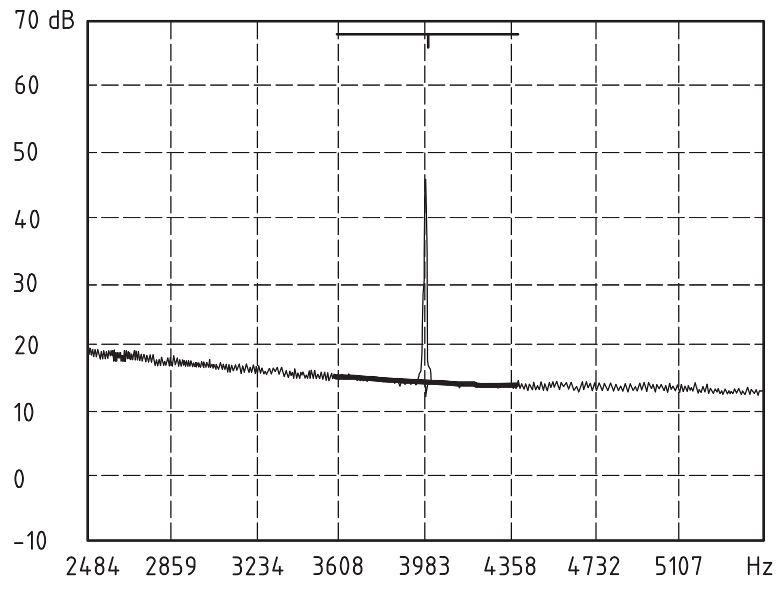
3 dB bandwidth of tone: 0.5% of 800 Hz

L_{pn} in critical band: 37.3 dB

Tonal audibility: ΔL_{ta} = 13.7 dB re MT

Adjustment: K_T = 6 dB

Figure D.3 — *Example 1*



D.3.3 Example 2

Critical band: 380 Hz – 480 Hz

Tones: 395 Hz, 53.1 dB and 468 Hz, 47.0 dB

Tonal level: L_{pt} = 54.1 dB

3 dB bandwidth of tone: 3.1% of 100 Hz

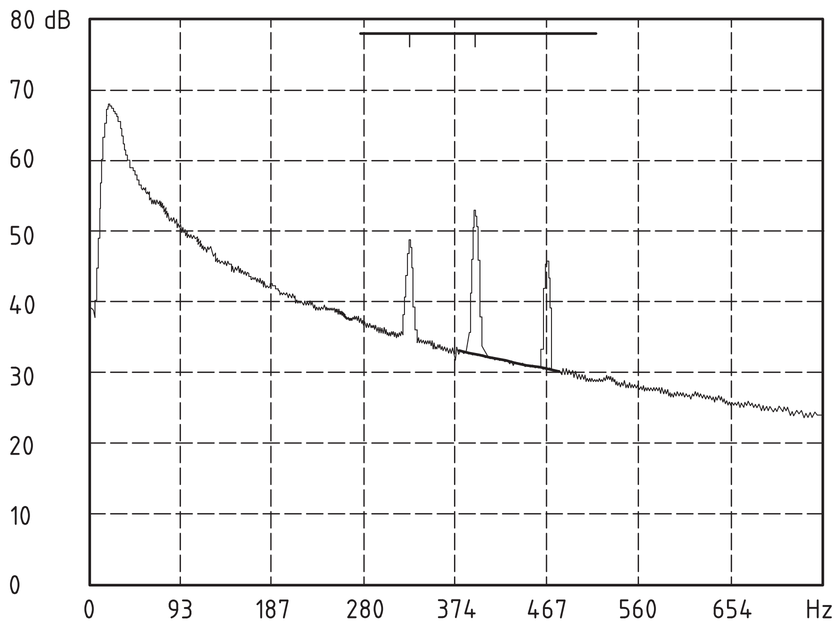
L_{pn} in critical band: 45.2 dB

Tonal audibility: ΔL_{ta} =11.1 dB re MT

Adjustment: K_T = 6 dB

NOTE The two tones with the highest frequencies give the highest ΔL_{ta}.

Figure D.4 — *Example 2*



D.3.4 Example 3

Critical band: 258 Hz – 358 Hz

Tones: 278 Hz, 33.3 dB

299 Hz, 38.4 dB

319 Hz, 54.3 dB

334 Hz, 37.1 dB

Tonal level: L_{pt} = 54.6 dB

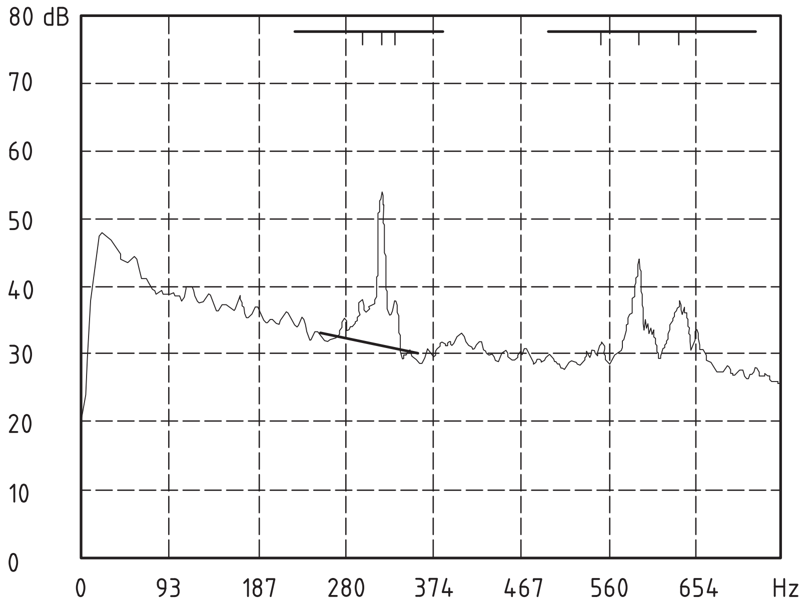
3 dB bandwidth of tone: 3.4% of 100 Hz

L_{pn} in critical band: 45.5 dB

Tonal audibility: ΔL_{ta} = 10.6 dB re MT

Adjustment: K_T = 6 dB

Figure D.5 — *Example 3*



D.3.5 Example 4

Critical band: 680 Hz – 830 Hz

Tone is varying between 680 Hz and 758 Hz

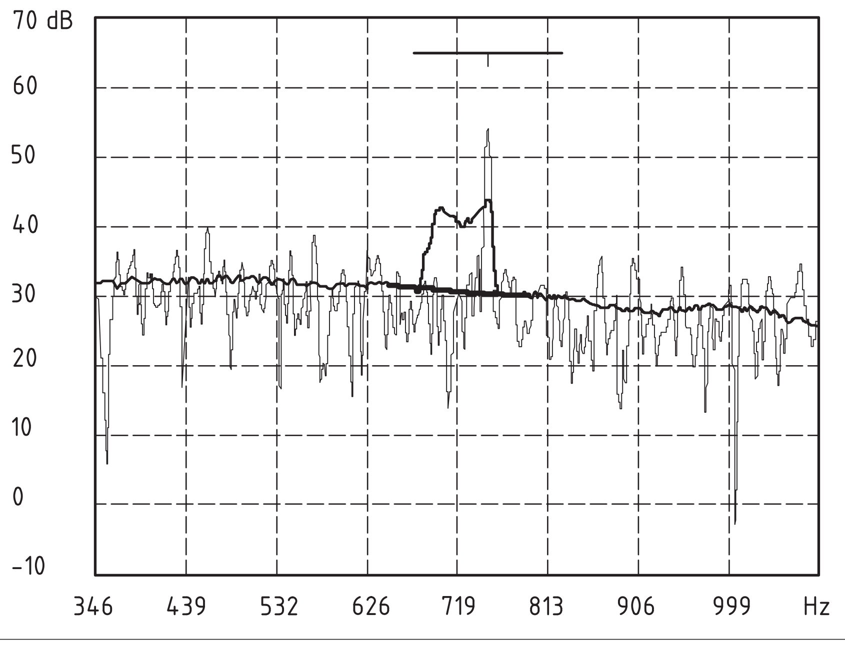
Tonal level: L_{pt} = 53.6 dB

L_{pn} in critical band: 45.5 dB

Tonal audibility: ΔL_{ta} = 10.7 dB re MT

Adjustment: K_T: = 6 dB

Figure D.6 — *Example 4*



NOTE The graph shows both an averaged spectrum and an instantaneous spectrum. The tonal level may either be found by energy summation of the lines in the broad maximum in the averaged spectrum or by averaging the tone levels from a number of spectra measured with short averaging time, giving the same total averaging time.

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

E.1 Introduction

Measurements carried out according to this annex yield as the main result a measure for the prominence of impulsive sounds. The method is intended to determine the prominence of impulsive sounds in correspondence with average subjective judgements made by listeners. Based on the prominence, P, a graduated adjustment, K_I, to the measured L_{Aeq} is defined.

The adjustment to L_{Aeq} for impulses depends on how prominent the impulsive characteristics are perceived through the continuous part of the sound including residual sound.

The method in this annex is derived from Nordtest Method NT ACOU 112 [7] and is not intended for use with gunfire sound and high-energy impulsive sound.

E.2 Definitions

Sound pressure levels, L_{pAF}, are A-weighted levels with time weighting F.

E.3 Impulse

The sudden onset of a sound is defined as an impulse.

NOTE The definition includes only the onset of a sound, not the sound as a whole. "Sudden" is based on an auditive judgement, which is expressed in terms of physical measurements in this annex.

The character and prominence of the impulse depend on the character of the emitted sound, on the distance and propagation path from the specific sound source and on the residual sound. The impulsiveness of a sound is characterized by the onset of the sound independently of the category of the sound source.

E.4 Onset

The onset of a sound is defined as the part of the positive slope of the time history of L_{pAF} where the gradient exceeds [A1⟩ 10 dB/s ⟨A1] (see Figure E.1).

The starting point of an onset is the point where the gradient first exceeds [A1⟩ 10 dB/s ⟨A1]. The end point of an onset is the first point after the starting point where the gradient decreases to less than [A1⟩ 10 dB/s ⟨A1]. Irregularities (on the onset) shorter than 50 ms are disregarded.

E.5 Level difference

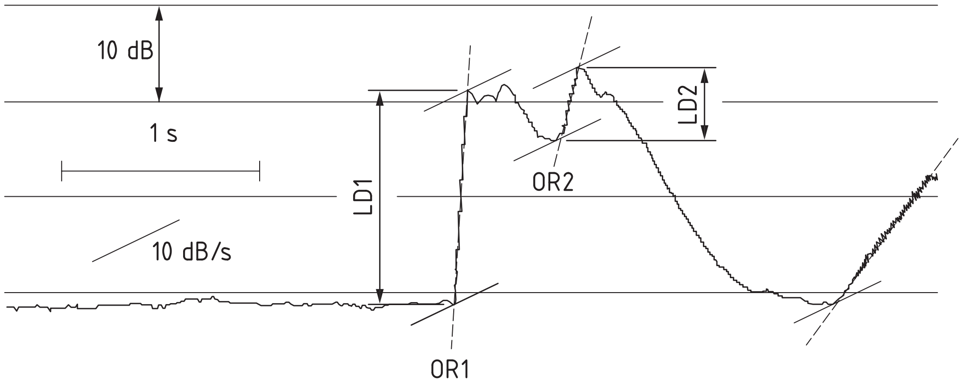
The level difference of an impulse is the difference in dB of L_{pAF} between the level of the end point L_e and the level of the starting point L_s of the onset.

E.6 Onset rate

The onset rate is the slope in [A1⟩ dB/s ⟨A1] of the straight line that gives the best approximation to the onset.

Figure E.1 — *Time history of the A-weighted sound pressure levels with time weighting F*

Le-(*Le*-*Ls*)/2 to *Le*



NOTE The figure illustrates the onset rate (OR) and the level difference (LD) for the two most prominent impulses. Gradients of 10 dB/s are indicated with short line segments.

E.7 Measurements

Measurements are made on the basis of L_{pAF}, the A-weighted sound pressure level with time weighting F. The electric noise floor of the measuring set-up need to be at least 10 dB lower than the acoustic background sound level. Special care is needed to ensure that the system is not overloaded during measurement.

The measurements may be performed by either digital or analogue methods, or a combination of these.

E.8 Digital recording and signal processing

The A-weighted sound pressure level with time weighting F is sampled with time intervals in the range from 10 ms to 25 ms. Measurements made on the basis of short-term L_{Aeq}-values (e.g. 10 ms) are approximated (e.g. by computation) to time weighting F before the readings are taken.

NOTE Measurements based on a series of short-term LAeq-values may be converted to a series of LpAF–values by the following formula:

[A1⟩ $$L_{\mathrm{pAF},n} = 10\lg\left\{\frac{\left[(\tau/\Delta t - 1)10^{L_{\mathrm{pAF},n-1}/10} + 10^{L_{\mathrm{Aeq},n}/10}\right]}{(\tau/\Delta t)}\right\} \quad (E.1)$$ ⟨A1]

where:

$L_{Aeq,n}$ the *n*th short-term L_{Aeq}-value;

$L_{pAF,n}$ A-weighted sound pressure level with time weighting F at the time of the *n*th

L_{Aeq}-value, $L_{Aeq,n}$; τ time constant for the time weighting. For F: τ = 125 ms; and

Δt time between the L_{Aeq}-values (and the integration time).

From a successive series of sound pressure levels with time weighting F, $L_{pAF,n}$, the starting point $n = s$ and the end point $n = e$ of an onset are defined from the procedure a) to d).

a) [A1⟩ The starting point, *s*, is the first point where the slope is larger than 10 dB/s:

$$L_{s+1} - L_s > \frac{10}{f}\left[\frac{\text{dB/s}}{1/\text{s}}\right]$$ ⟨A1]

b) The end point *e* is the first point after the starting point where the slope is less than [A1⟩ 10 dB/s:

$$L_{e+1} - L_e \frac{10}{f}\left[\frac{\text{dB/s}}{1/\text{s}}\right]$$ ⟨A1]

c) A new starting point occurs when condition a) is met again.

d) If a new starting point *s1* occurs within a period of 50 ms after the end point *e*, then end point *e* and start point *s1* [A1⟩ shall be neglected if the following conditions are met:

$$\frac{(L_{e1} - L_e)}{(t_{e1} - t_e)} > 10\,\text{dB/s and } \frac{(L_{s1} - L_s)}{(t_{s1} - t_s)} > 10\,\text{dB/s}$$ ⟨A1]

[A1⟩ Where *e1* is the end point after the new starting point *s1*. If point *e* is neglected, point *e1* takes over the name *e*. *s+1* denotes the point one sample after point *s*. L_s is the point of level *s*, and t_s is the time of sampling; L_e is the level of point *e* and t_e is the time of sampling, and so on. *f* is the sampling frequency.

For each onset the level difference is L_e - L_s, and the onset rate is found from the "least squares method" (linear regression) of the points from *s* to *e* (incl.). ⟨A1]

E.9 Analogue recordings

For analogue recording care needs to be taken that the vertical writing speed (the level) is not limited by the writing system. For recordings in true time a writing speed of at least [A1⟩ 1 000 dB/s ⟨A1] is necessary.

For visual readings of the onset rate from level recordings, the horizontal speed (the time) needs to be sufficient to ensure a satisfactory accuracy of the gradient of the onset. A slope of 45 ° is recommended.

For the approximation of the onset to a straight line, irregularities shorter than 50 ms on the generally increasing curve (even decreasing levels) do not indicate the start of a new onset.

E.10 Predicted prominence, *P*

In periods of half an hour a number of impulses with the apparently highest onset rates and level differences are selected. For sound with shorter duration the impulses are selected during the whole period. For each selected impulse the predicted prominence *P* is calculated from:

[A1⟩ *P* = 3lg (onset rate) + 2lg (level difference~~)~~

where the "onset rate" in dB/s ⟨A1] and the "level difference" in dB are as defined in in E.6 and E.5, respectively. The impulse with the highest value of *P* gives the final result.

NOTE The general form of the expression for P is: P = k_1 . lg (onset rate) + k_2 . lg (level difference). The constants k_1 and k_2 have been estimated from the results of listening tests. It is also taken into account that the relation *between P for very sudden and loud impulses and P for slow level changes is large. P was furthermore designed to give a maximum around 15.*

E.11 Adjustment to L_{Aeq}

For sounds with onset rates larger than [A1] 10 dB/s [/A1] the following adjustment K_I, based on the predicted prominence P, may be applied:

$K_I = 1.8\ (P - 5)$ for $P > 5$

$K_I = 0$ for $P \leq 5$.

E.12 Examples

The examples given in Table E.1 are taken from Holm Pederson [8].

Table E.1 — *Examples of the prominence P and the adjustment K_I for different sound sources*

Sound source	**L_{AFmax} dB**	**Level diff. dB**	**Onset rate [A1] dB/s [/A1]**	**Prominence *P***	**Adj. K_I dB**
Background sound $L_{PA,F}$ = 40 dB					
Tyre change, pneumatic tool, L	48	7	38	6.4	2.6
Tyre change, pneumatic tool, H	67	17	76	8.1	5.5
Compressed air release, L	48	9	65	7.3	4.1
Compressed air release, H	67	27	140	9.3	7.8
Metal hammering, L	54	15	194	9.2	7.6
Metal hammering, H	75	35	222	10.1	9.2
Wood axe, L	52	13	125	8.5	6.4
Wood axe, H	72	17	353	10.1	9.2

NOTE Other results occur for different conditions of distance, propagation path and background noise. L and H indicate L_{Aeq} values of 40 dB and 60 dB, respectively, from the sound sources.

E.13 Accuracy and uncertainty

It has been found [7, 8] that the mean standard deviations of the results of sixteen different noise examples from four laboratories using four different measuring set ups was 0.3 on the prominence P and 0.6 dB on the adjustment K_I.

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