Environmental Protection Agency
Office of Environmental Enforcement (OEE)

DRAFT Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)

2024

Acknowledgements

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Supersession

This document supersedes the following Agency publication, which is withdrawn with immediate effect:

Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) (January 2016).

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EXECUTIVE SUMMARY

This Guidance Note is intended to assist EPA licensed sites to manage noise from their facility. Noise management entails both preventing as much as possible or at least minimising noise during design stages and implementing a Noise Management Plan during the operational phase, which is updated periodically.

This Guidance Note is also intended to assist licensed sites with the assessment of their potential and actual noise impact on the local environment. It provides the relevant knowledge and guidance to licensees together with their consultants, regulators and interested third parties. This document updates and supersedes the *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4, January 2016)* and it incorporates noise measurement and assessment techniques specified in updated standards since this time.

The document is not intended for use for windfarm developments, road or rail noise or construction noise.

The Guidance Note is divided into fourteen sections and an overview of each section is provided in the introduction. A new dedicated section is provided with up-to-date information on the Environmental Noise Regulations, National Plan Framework regarding noise policy, IPC/BAT and the standards used for environmental noise assessment purposes, including ISO1996, ISO9613 and BS4142, referenced throughout the document.

The Guidance updates and extends the information on Noise Basics (fundamentals) with diagrams and examples. Links to sound files (QR Codes) to aid explanation of some noise concepts are provided in this and subsequent sections, to enhance the reader's understanding of the noise principles outlined.

Examples of the qualifications, training and experience required by the competent person are updated and summarised in this document. It is accepted that an individual may not possess all the attributes listed e.g. an individual may have the competency to undertake basic noise measurement, but not in more complicated surveys, analysing and interpreting noise data (e.g. identifying tonal or impulsive noise), or in designing solutions for noise control, but the competent person, required for all elements of noise management at EPA licensed sites, will have the ability to recognise when more specialist expertise may be needed.

The approach to be considered when applying for an EPA IE, IPC or Waste Licence for identifying appropriate environmental noise criteria follows similar steps as outlined in the previous guidance, with updated information on the treatment of industrial noise from licensed sites within the three agglomerations of Dublin, Cork and Limerick falling within the scope of the Environmental Noise Regulations which requires consideration for licence applications within these areas.

The guidance presents and updates pertinent information regarding the four stages required for noise assessment during a licence application. The assessment of noise impact (stage 3) is expanded to include assessment using calculation methods / ISO 9613, Noise Modelling and BS4142*:2014+A1:2019 Methods for rating and assessing industrial and commercial sound.*

The practical requirements for conducting Environmental Noise Compliance Survey Reports for a licensed site follows the same advice provided in the previous guidance, with a more comprehensive outline on the level of detail required. If the EPA deem that an Environmental Noise Compliance Survey Report is incomplete or does not contain enough information to allow a valid assessment of noise impact to be made in line with this Guidance, then the report can be rejected and further assessment may be requested.

This guidance provides updated comprehensive information on the methods of measurement and assessment of tonal noise, low frequency and impulsive noise in three separate sections, as these characteristics are common and may be poorly understood features in environmental noise measurement, which can cause annoyance and lead to complaints. Other sound characteristics that may sometimes cause annoyance are also discussed.

Two standard methods for the identification of tonal noise are provided in the guidance, in addition to subjective determination: 1/3 Octave Analysis must always be used and Narrow Band Frequency Analysis (Fast Fourier Transform - FFT) is to be used in appropriately defined circumstances. A further method to aid subjective determination of tones by narrowband frequency analysis using a smartphone app is provided in Appendix 4. It is known that 1/3 octave band analysis may not be sufficiently sensitive to identify a tone in all cases and will often indicate there are no tones where tones are actually present. The preferred method, especially where there is doubt, is to use narrow band (FFT) analysis, which can be conducted post monitoring on audio recordings using specialist software and/ or in the field using dedicated FFT programmes. Tonal penalties are updated in this guidance in line with current standards and a penalty of up to 6dB may be appropriate, depending on the circumstances. Tonal penalties are automatically assigned when using FFT software packages.

The section on low frequency noise, which is generally taken to mean noise below a frequency of about 200Hz outlines that many of the assessment and control techniques which pertain to everyday noise sources do not apply to low frequency noise, which make it difficult to detect and mitigate against. Three methods for determining low frequency noise are provided; Subjective & Audio Screening; NANR45 and Narrow Band Frequency Analysis.

The section on impulsive noise and other sound characteristics provides examples of regular, highly impulsive and high energy impulsive noise, from current standards. Impulsive noise is normally easily identifiable subjectively but where there is any doubt, then an objective calculation method is outlined, which is conducted using acoustic software. Impulsive penalties are updated in this guidance in line with current standards and a recommended impulsive penalty of up to 5dB may be appropriate for regularly impulsive sound sources or 12dB for highly impulsive sound sources, depending on the circumstances.

The guidance highlights the importance of identifying intermittent noise and other sound characteristics in a noise survey where they are a source of complaint. Two methods for identifying intermittent noise are provided.

This guidance changes the requirement to add more than one penalty adjustment at a noise sensitive location if noise is both tonal and/or impulsive, in line with current standards. The previous guideline referred to applying a single adjustment penalty only and this is no longer the case.

A summary of the standard methods recommended in this guidance for the determination of Tonal Noise, Low Frequency Noise, Impulsive Noise and Intermittent Noise, along with appropriate penalties is provided in Figure 20.

A new section on Noise Management Planning is included in this guidance to show the licensee how to consider noise at an early stage to control noise at source and also control the migration pathway. Some licences include a condition to prepare, maintain and implement a Noise Management Plan and a detailed step by step approach on how a competent person may diagnose a noise problem and assess Best Available Technique (BAT) solutions for noise control is provided.

The section on Noise Complaints is extended to provide information on how the public may make a noise complaint and how the licensee and the Agency may deal with a noise complaint. Steps to evaluate a noise complaint using the techniques outlined throughout the guidance are summarised in this section.

The section on Noise Control – Best Practice in Noise Mitigation is expanded with specific examples and sound files of noise control measures for three specific sources that are common causes of noise problems; 1) Fan Noise; 2) Vibrating Noise from Sieves, Screens, Conveyors or Separators and 3) Generator Sets and Other Engines. This section also outlines the general noise control techniques that can be applied to a range of noise problems encountered on industrial sites.

Additional details on three specific activities that commonly take place on licensed facilities; quarrying and mining operations, wind turbines and waste related activities follows the same advice provided in the previous guidance, with minor updates.

An updated glossary is provided at the end of the guidance with relevant terms used throughout the document.

This Guidance is a comprehensive document that must be read and understood by those engaged in Noise Assessments for Licensed Sites. A separate HOW TO USE this Guidance note has also been prepared, which guides the reader to the relevant section of NG4 depending on their requirements.

PREFACE

The Environmental Protection Agency (the Agency) administers a wide range of licensing, enforcement, assessment and monitoring activities that could have an impact on the environment. The Office of Environmental Enforcement (OEE) is one of the five offices in the Environmental Protection Agency, and it is dedicated to the implementation and enforcement of environmental legislation in Ireland.

- It is directly responsible for enforcing EPA licences granted to waste, industrial and other activities such as local authority wastewater treatment plants.
- It prosecutes or assists in the prosecution of significant breaches of environmental protection legislation.
- It is the quality regulator for drinking water and urban wastewater treatment plants operated by Irish Water.
- It supervises the environmental protection activities of local authorities by auditing their performance, provision of guidance and working through NIECE (Network for Ireland's Environmental Compliance and Enforcement).

It is the policy of EPA to provide support, advice and guidance and to publish clear guidance outlining what they expect from those they regulate. This guidance document relates specifically to environmental noise from scheduled activities and can be considered when preparing the noise section of a licence application, when conducting noise surveys to assess compliance with licence conditions, when assessing environmental noise complaints and when determining the best available solutions for noise control. This guidance document has been prepared in consultation with the public, stakeholders and the regulated community.

A separate HOW TO USE this guidance note has also been prepared, which provides a short summary to guide the reader to the relevant section of NG4, depending on their requirements.

Another noise guidance document is provided by the EPA for scheduled activities: Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3). Where wind turbines exist on licensed sites, both NG3 & NG4 can be considered.

The EPA is responsible for the management of noise relating to scheduled activities (licensed sites). Noise from all other industrial activities fall under the remit of the Local Authority in whose functional area the activity takes place. Noise from major roads, major rail, major airports and major agglomerations are also dealt with by Local Authorities under their Noise Action Plan following separate EPA guidance documents. Where a scheduled (licensed) activity occurs in an agglomeration, this activity also falls under the remit of the EPA.

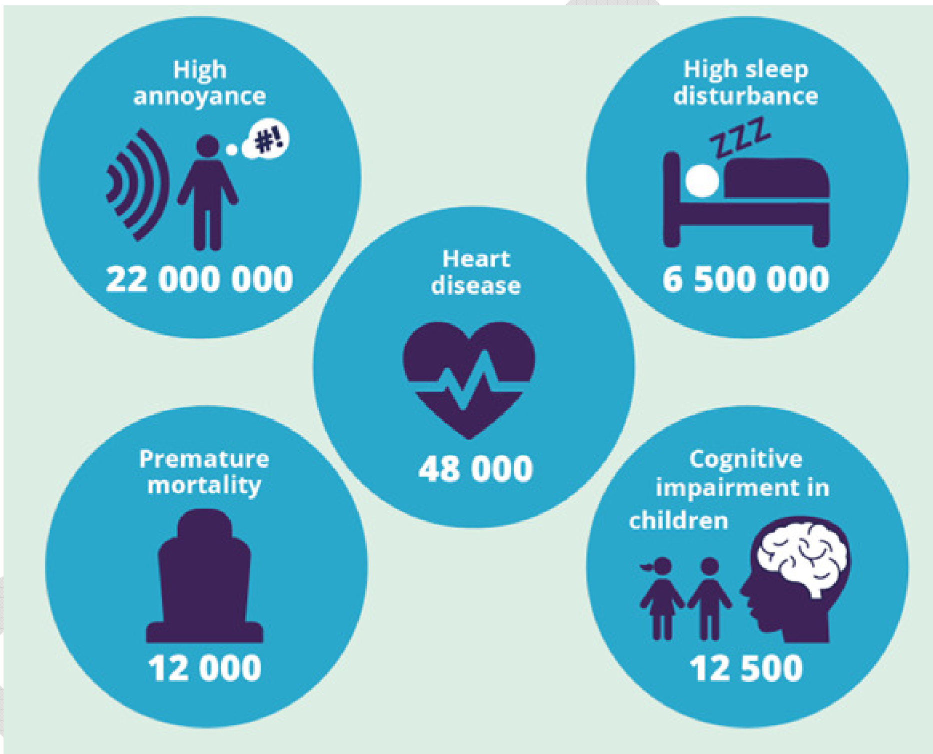
As are all EPA guidance documents, NG4 is subject to periodic review and amendment. The most recent version is available on the EPA website: http://www.epa.ie/.

Web links in this document were validated prior to publication. Over time, some of these links will go out of date. The reader is advised to visit www.epa.ie to obtain the most up to date version. If the reader experiences difficulty in finding any of the referenced sources, please contact airthematic@epa.ie.

1.0 INTRODUCTION

Environmental noise is 'unwanted sound' arising from all areas of human activity such as noise from transport, industrial and recreational activities. The World Health Organisation (WHO) defines health as "a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity" and according to the WHO, environmental noise features among the top environmental risks to physical and mental health and well-being. WHO statistics on the number of people affected by Environmental Noise in Europe is shown in Figure 1.

Figure 1. Impacts of Environmental Noise in Europe[1]



Excessive noise is known to:

- Seriously harm human health, including mental health;
- Interfere with people's daily activities at school, at work, at home & during leisure time;
- Disrupt sleep, cause cardiovascular and psychophysiological effects;
- Lower performance, lead to annoyance responses and changes in social behaviour.

The primary objective of this guidance note is to provide practical information and advice in respect of those activities that are listed in the First Schedule to the Environmental Protection Agency Act 1992, as amended, the Third and Fourth Schedules of the Waste Management

1. European Environment Agency (2020): EEA Report No 22/2019 -*Environmental noise in Europe — 2020*.

Act 1996, as amended, and the Protection of the Environment (PoE) Act 2003. This guidance note will assist operators of licensed sites and inspectors to understand what is required to ensure compliance with noise related limits and conditions set out in the license for their activity.

The guidance note can also be used by acoustic professionals, consultants, planners, regulators, the public and interested third parties. This document supersedes the Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) (January 2016). It aims to provide clear guidance on minimising noise impact in the design and operational phase of a licensed facility, along with methodologies for monitoring and assessment of noise, to assess compliance with Licence conditions, which will ensure the protection of the environment and its citizens from noise pollution.

1.1 Description of Guidance Note Sections

The guidance document is laid out in the following sections and a broad overview of the content of each section and who the section is aimed at is also listed. It is, however, recommended that the entire document is reviewed to ensure a comprehensive understanding of environmental noise management for licensed activities.

Section 2 All Users	**Noise Regulations, Policy & Standards** - This section describes the main regulations in Ireland relating to Environmental Noise for licensed activities, national policy relating to noise and the main noise standards referenced throughout this document used for noise assessment purposes.
Section 3 All Users	**Noise Basics** - This section provides the lay reader with an introduction to the basic principles of acoustics in order to assist with the interpretation of some of the more technical aspects of the document.
Section 4 Licensees / Acoustic Engineers	**Competent Person** - This section outlines the minimum requirements/experience that should be clearly demonstrated by a competent person completing the noise section of a licence application or carrying out annual noise surveys, complaint investigations and noise mitigation. The necessity for a competent person is referenced throughout the document.
Section 5 Licensees / Acoustic Engineers	**Environmental Noise Criteria** - This section outlines a detailed approach to be followed by a facility applying for an IE, IPC or Waste Licence in relation to identifying and applying appropriate noise criteria to the facility.
Section 6 Licensees / Acoustic Engineers	**Noise Assessment for Licence Applications** - This section presents additional guidance to supplement the information contained within the relevant Licence Application Forms and Guidance Notes for Licence Applications. It expands on guidance in relation to the level of detail and information that should be submitted as part of the licensing process.

Section 7 Licensees / Acoustic Engineers	**Environmental Noise Surveys** – This section deals with issues that need to be considered by the competent person in relation to carrying out noise survey work associated with Licenced sites. Whilst not exhaustive, the section covers issues such as minimum monitoring periods, equipment, calibration, weather and information to be contained within noise reports.
Section 8 Licensees / Acoustic Engineers	**Tonal Noise** – This section presents detailed information on how to assess if tonal noise is present on a site and two standard methods are outlined. The importance of narrowband frequency analysis in the determination of tones is highlighted. Penalties to be applied to achieve a noise rating level for a site are also provided.
Section 9 Licensees / Acoustic Engineers	**Low Frequency Noise -** This section describes what low frequency noise is and how it is not adequately detected by A-weighting L_{Aeq} noise readings, nor by 'common noise' assessment techniques. Three methods to determine if low frequency noise may be present on a site are provided.
Section 10 Licensees / Acoustic Engineers	**Impulsive Noise & Other Sound Characteristics –** This section outlines a range of impulsive sound sources that may be present on a licensed site and two methods of assessing impulsive noise is provided. Two methods for the assessment of intermittent noise are also provided along with a discussion of other sound characteristics. Relevant penalties for impulsive noise and other sound characteristics are provided.
Section 11 Licensees / Acoustic Engineers	**Noise Management Planning –** This section outlines how noise may be managed at a licenced facility by proper planning. A site-specific Noise Management Plan will outline steps to prevent noise and where excessive noise is already an issue, how to diagnosis the problem.
Section 12 All Users	**Noise Complaints** – This section outlines how a noise complaint may be made to a licensed site and what is expected of the site once a complaint is made. A complaint cause-evaluation process is outlined to determine if the noise source is attributed to the licensed site and what further steps may be required for noise control and mitigation at the licensed site.

Section 13
All Users

Noise Control – Best Practice in Noise Mitigation – This section outlines optimum noise control measures from three common noise generating sources; fans, vibrating sources and engines. Examples of noise control from these sources using the measurement and diagnostic techniques outlined in previous sections are provided. General noise control techniques that can be used for a variety of noise problems are provided, including vibration damping and vibration isolation, enclosure, barrier, lagging and control of reverberation. The importance of controlling noise at source is highlighted as this is usually more effective than secondary containment. Alternatively, a combination of source and pathway noise control measures is commonly used.

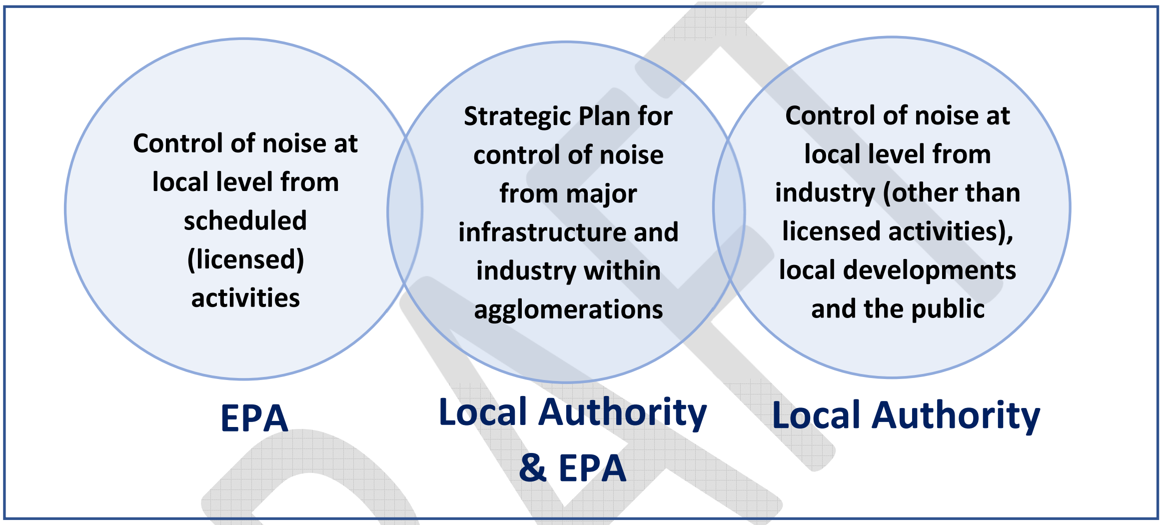
Section 14
Licensees / Acoustic Engineers

Specific Activities – This section provides additional detail on three specific activities that commonly take place on licensed facilities; quarrying and mining operations, wind turbines and waste related operations. Additional publications and guidance relevant to these activities, where they may impact on environmental noise are outlined.

2.0 NOISE REGULATIONS, POLICY & STANDARDS

Existing legislation relating to environmental noise in Ireland provides for the strategic control of noise from major infrastructure and industry within agglomerations. The legislation also provides for control of noise at specific sources and the method in which noise can be tackled at local level from licensed activities (regulated by the EPA) and from other activities (regulated by Local Authorities). Where environmental noise from industrial activities occurs within agglomerations, then the requirements of both strategic and local regulations need to be considered, as illustrated in Figure 2.

Figure 2. Framework & Responsibility for Environmental Noise Control



Noise regulations relating to licensed activities is covered in the following sections while noise from other activities regulated by the local authority is outside the scope of this document. Examples of guidelines relevant to noise from other activities (outside the remit of the EPA) are provided in the reference section.

2.1 Environmental Noise Regulations

The strategic control of environmental noise is directed by the European Communities (Environmental Noise) Regulations 2018 (S.I. No. 549 of 2018) and the European Communities (Environmental Noise) (Amendment) Regulations 2021 (S.I. No. 663 of 2021), which aim to provide a common framework to avoid, prevent or reduce on a prioritised basis the harmful effects of exposure to environmental noise from major infrastructure such as airports, major roads, and large agglomerations.

The Regulations implement the requirements of Environmental Noise Directives (END), specifically the EU Directive 2002/49/EC relating to the assessment and management of environmental noise, as amended by Commission Directive (EU) 2015/9965 establishing common noise assessment methods (CNOSSOS-EU).

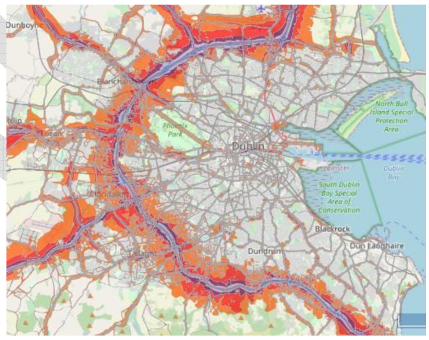
For the purposes of these Regulations, 'environmental noise' means unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, including major roads with >3 million passenger vehicles per year, major railways with >30,000 train passages per year, major airports with more than 50,000 movements per year and the noise (including industrial noise) within defined agglomerations of Dublin, Cork and Limerick.

The Regulations set out a two-stage process for addressing environmental noise:

1. Noise must be assessed through the preparation of strategic noise maps for areas and infrastructure falling within defined criteria, e.g. large agglomerations, major roads, railways and airports;
2. Based on the results of the mapping process, the Regulations require the preparation of noise action plans for each area concerned.

Every five years from the date of preparation of the noise maps and action plans, and whenever there is a major development affecting noise, the maps and plans are required to be reviewed and revised if necessary. The fundamental objective of action plans is to reduce the effects of environmental noise where necessary.

Primary responsibility for both noise mapping and action planning is assigned to local authorities and the regulations designate the Environmental Protection Agency as the National Authority for the purposes of the Regulations. The Agency's role includes supervisory, advisory and coordination functions in relation to both noise mapping and action planning, as well as reporting requirements for the purpose of the Directive.



The Regulations provide for strategic noise maps and action plans and revised noise maps and action plans to be made available to the general public. They also provide for public consultation on proposed action plans and the review of action plans, and for the results of public consultation to be taken into account in finalising action plans or review of action plans.

Within the three agglomerations, industrial noise from IE/IPC or Waste licensed sites falls within the scope of the Environmental Noise Regulations, and the Local Authority may consult with the Agency, where necessary, if the strategic noise mapping indicates that exposure to industrial noise may require mitigation. This is discussed further in Section 5.4.

In support of its role as national competent authority, the Agency has published guidance notes on Strategic Noise Mapping and Noise Action Planning, which sets out further practical information on implementation of the END in Ireland.

2.2 Regulation of EPA Licensed Sites

The Environmental Protection Agency Act 1992, as amended, the Waste Management Act 1996, as amended and the Protection of the Environment (PoE) Act 2003 brought about the system of an integrated approach to pollution control from industrial sources in Ireland. The EPA issue one of three types of licence to industrial activities that fall under scope of the First Schedule to EPA Act 1992 & 2003 as amended and the Third and Fourth Schedule of the

Waste Management Act 1996 as amended and these include an Industrial Emissions (IE) Licence, Integrated Pollution Control (IPC) Licence and Waste Licence.

As part of the licensing systems, certain scheduled activities and operations have conditions attached to their licences relating to noise and noise limits may be imposed at boundary positions and/or at noise sensitive locations. These Regulations allow for control of noise at local level for scheduled activities and activities falling under the regulations must adopt Best Available Techniques (BAT) for the control of environmental emissions, including noise, as detailed in the following section.

2.3 Best Available Techniques (BAT)

Best Available Techniques (BAT) was introduced as a key principle in the legislation and the European IPPC Bureau produce BAT reference documents (BREFs), for specific industries, all of which make reference to noise emission and techniques to control them https://eippcb.jrc.ec.europa.eu/reference.

BAT guidance documents normally specify a range of Environmental Quality Standards (EQS's) which are designed to limit the concentration of pollutants in specified environmental media to a definitive quantitative level. Noise is unlike many other pollutants, however, in that there is typically no residual effect and once the noise emission ceases, the acoustical energy attributable to it is eliminated until the emission recommences. Noise is also different in that its potential impact is dependent on a wide range of factors such as:

- The subjective loudness/the measured sound pressure level;
- The sensitivity of any individuals affected;
- The time and duration of emission;
- The nature of the source;
- The location of noise sensitive receptors;
- The ambient and background noise levels;
- The nature and character of the locality, and;
- The presence or otherwise of special acoustic characteristics such as tones and/or impulsive elements.

The principle of BAT should be employed to control noise emissions from all licensed activities. Whilst this guidance note does not constitute a statement of BAT for noise it does deal in general terms with the approach to be taken in the regulation, assessment and control of noise in the design and operation of relevant activities. Specific examples of BAT or Best Practice for the control of industrial noise sources is provided in Sections 11 & 13 and these should always be considered at an early stage in the planning and development of a site.

2.4 Environmental Protection Agency Act - Sections 106 to 108

Three sections of the Environmental Protection Agency Act 1992 (Sections 106 to 108) specifically refer to noise and they give power to the Agency (and Local Authority) to deal with noise on a smaller scale, to ensure that it is managed and controlled at local level from licensed sites.

- **Section 106** deals with the making of regulations for noise control by the Minister and the Agency;
- **Section 107** sets out the powers prescribed by the Act to a local authority or the Agency to prevent or limit noise. This allows local authorities or the Agency to serve notices on premises/sites where prevention or limitation of noise is required. The Environmental Protection Agency Act 1992 (Noise) Regulations 1994 provide for a prosecution where there is a failure to comply with the requirements of the issued notice, and;
- **Section 108** describes the provisions for complaints regarding noise to be taken to the District Court by any person or agency. It allows for any person, local authority or the Agency to make a complaint to the District Court where noise levels are considered to be generating a reasonable cause for annoyance. Where the court finds in favour of a noise complaint, the person or body responsible for the noise must reduce it to a specific level, to limit it or cease it altogether.

2.5 Noise Measurement and Assessment Standards

There are a number of key standards referenced throughout this guidance that outline the requirements for environmental noise measurement, prediction and assessment. Both international standards (ISO) and British Standards (primarily BS4142) are referenced, as these are widely used and provide standard methods of assessment and analysis of environmental noise. In certain other instances the approach to identifying appropriate criteria outlined in this document may be considered suitable. In all cases, the methodology used for noise assessment should be considered and justified by a competent person and documented in the noise survey report.

The following standards must be understood and followed for noise assessment purposes for licensed facilities.

ISO 1996-1:2016 *Acoustics — Description, measurement and assessment of environmental noise — Part 1: Basic quantities and assessment procedures.*

This standard defines the basic quantities to be used for the description of noise in community environments and describes basic assessment procedures. Subjective determination of impulsive noise is also detailed in this standard.

ISO 1996-2:2017 *Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of sound pressure levels*

This standard describes how sound pressure levels intended as a basis for assessing environmental noise limits or comparison of scenarios in spatial studies can be determined. Determination can be done by direct measurement and by extrapolation of measurement results by means of calculation. The standard includes a methodology for evaluating and correcting the measured noise level allowing for any tonal content using an Engineering method (Annex J) and a Survey Method (Annex K).

ISO/PAS 1996-3:2022 *Acoustics — Description, measurement and assessment of environmental noise — Part 3: Objective method for the measurement of prominence of impulsive sounds and for adjustment of* L_{Aeq}

This method objectively categorises sources by determination of the prominence of impulsive sound, with the aim of correlating to community response. ISO/PAS 1996-3:2022 (Publicly Available Specification) is an ISO publication with a relatively short validity after which it must be withdrawn or converted to another ISO document such as a full standard. The most recent version of the standard must be used for noise assessment and compliance purposes.

ISO 9613-1:1993 *Acoustics Attenuation of sound during propagation outdoors Part 1: Calculation of the absorption of sound by the atmosphere*

This standard specifies an analytical method of calculating the attenuation of sound as a result of atmospheric absorption for a variety of meteorological conditions.

ISO 9613-2:2024 *Acoustics Attenuation of sound during propagation outdoors Part 2: General method of calculation*

This standard describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level (as described in ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.

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

This standard provides a method of assessing the impact of a source of industrial or commercial sound including sound from industrial and manufacturing processes and fixed installations. BS4142 may be used when introducing new equipment on existing sites, particularly in areas of low background noise, or for new facilities to determine the likelihood for adverse significant effects. Notwithstanding this, in order to assess the audibility of tones and the prominence of impulsive sounds the preferred methods are those specified in the ISO Standards above. A BS4142 may aid assessment of new noise sources, but the licenced site is assessed against appropriate day, evening and night time noise limits in all cases.

Two standard methods for the identification of tonal noise are provided in the guidance, in addition to subjective determination: 1/3 Octave Analysis must always be used, and Narrow Band Frequency Analysis (Fast Fourier Transform - FFT) is to be used in appropriately defined circumstances. 1/3 octave band analysis may not be sufficiently sensitive to identify a tone in all cases, and will often indicate there are no tones where tones are present. The UK Environment Agency published a Method implementation document (MID) for BS 4142 (Updated 22 December 2023), to provide extra guidance on the implementation of this standard.

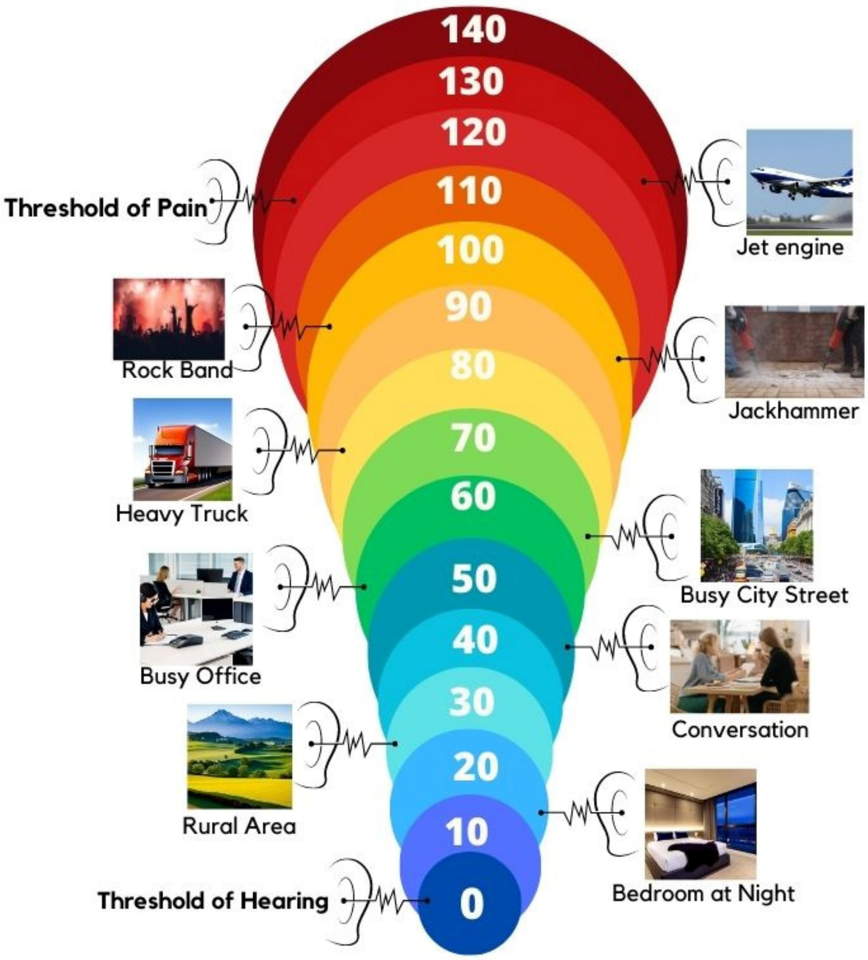
3.0 NOISE BASICS

Environmental Noise is “unwanted sound”. Sound is produced by vibrating objects that reaches the listener's ears as waves in the air or other media (sound waves). Simply put, sound may be described as a variation in atmospheric pressure that is detected by the human ear and results in the sensation of hearing. The greater the pressure change, the louder the sound. The difference between sound and noise depends on the listener and the circumstances; for example, rock music can be pleasurable to one person and an annoying noise to another.

The human ear is a very sensitive anatomical organ and can detect a wide range of fluctuations in pressure levels, from the quietest whisper to a jet engine at take-off. In order to represent this range of detectable pressure changes in a more efficient manner, sound is typically measured in terms of a logarithmic scale of sound pressures. These values are expressed as Sound Pressure Levels (SPL) in decibels (dB). In terms of sound pressure levels, audible sound ranges from 0dB (i.e. the threshold of hearing) to the threshold of pain at 120dB.

An indication of the level of some common sounds on the L_{pA}(dB) scale is presented in Figure 3.

Figure 3. Decibel Scale



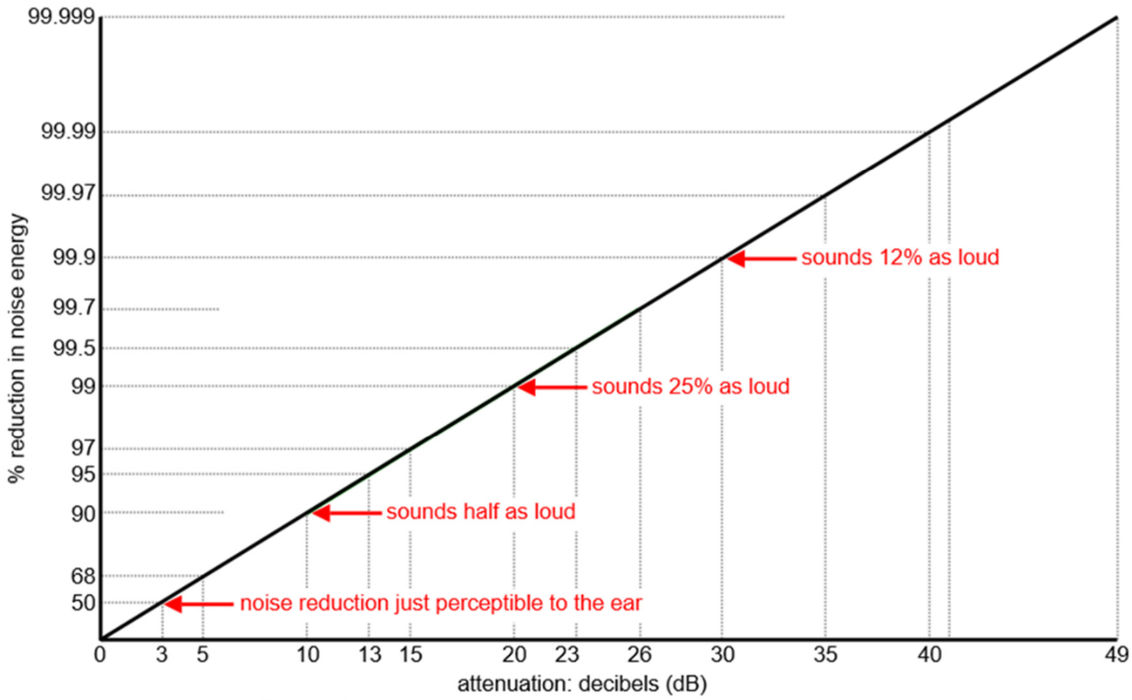
A doubling or halving of pressure equates to a 3dB increase / decrease in decibel level. Typically, under normal circumstances, a 3dB change in environmental noise level is the smallest noticeable to the human ear. A 10dB increase / decrease in sound level normally equates to a subjective doubling / halving of noise.

This is demonstrated in Figure 4. Noise Attenuation Chart, which plots the relationship between noise energy and decibels. As an example, a 10dB attenuation means that the sound energy has been reduced by 90%, but it sounds about half as loud. For a 23dB attenuation, the figure is a 99.5% energy reduction and subjectively about a quarter as loud.

It is important to understand the implications of noise energy reduction when it comes to reducing noise levels from an industrial site. A scarcely subjectively detectable 3dB reduction requires the operator to cut the total noise energy by 50%, which could be very costly.

QR Codes and sound files for a breaker are provided with the chart to allow the reader to hear what the breaker noise sounds like when reduced by 3dB, 10dB and 20dB.

Figure 4. Noise Attenuation Chart



0dB attenuation breaker.mp3

3dB attenuation breaker.mp3

10dB attenuation breaker.mp3

20dB attenuation breaker.mp3

0dB Attenuation **3dB Attenuation** **10dB Attenuation** **20dB Attenuation**

Noise levels can be represented using a variety of parameters and weightings, which the reader should be aware of; these are outlined in the following sections. A Glossary is also provided in Appendix 1.

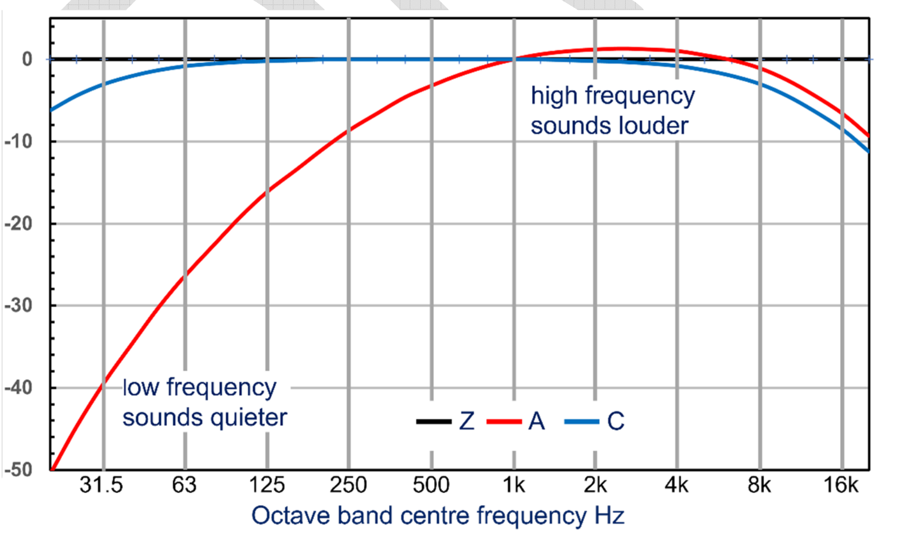
A, C & Z Weighting

The dB(A) is the overall single-figure noise level using the "A" weighting filter. The frequency of sound is the "pitch" and is expressed in Hertz (Hz). Human hearing is less sensitive at very low and very high frequencies, that is to say it is not uniform across the sound spectrum. In order to account for this weighting, filters are commonly applied when measuring and/or assessing sound. The most common frequency weighting in current use is 'A-weighting'. This weighting mechanism conforms approximately to the response of the human ear at moderate levels. Sound pressure levels measured using 'A-weighting' are expressed as L_{pA}(dB), as shown in Figure 5 (red line). This line represents what humans are physically capable of hearing.

The dB(C) is represented by the light blue line in Figure 5. The C-Weighting curve represents what humans hear when the sound is turned up i.e., we become more sensitive to the lower frequencies. The C-weighting filter is often applied to measurements when representing peak levels. The A and C weightings are the most meaningful for describing the frequency response of the human ear toward real world sounds.

The dB(Z) (or dB(L)) is the un-weighted or linear noise response shown by the dark blue line in Figure 5. It is the overall single figure noise level with no filters i.e., it gives equal weight to all frequencies. The Linear Weighting or Z-Weighting (no weighting and thus no filter) may be applied, for example, where an **analysis of the sound source** is required rather than the effect the sound has on humans or where low frequency sound is under investigation.

Figure 5. A, C & Z Weighting Filter Shape



A-weighted music

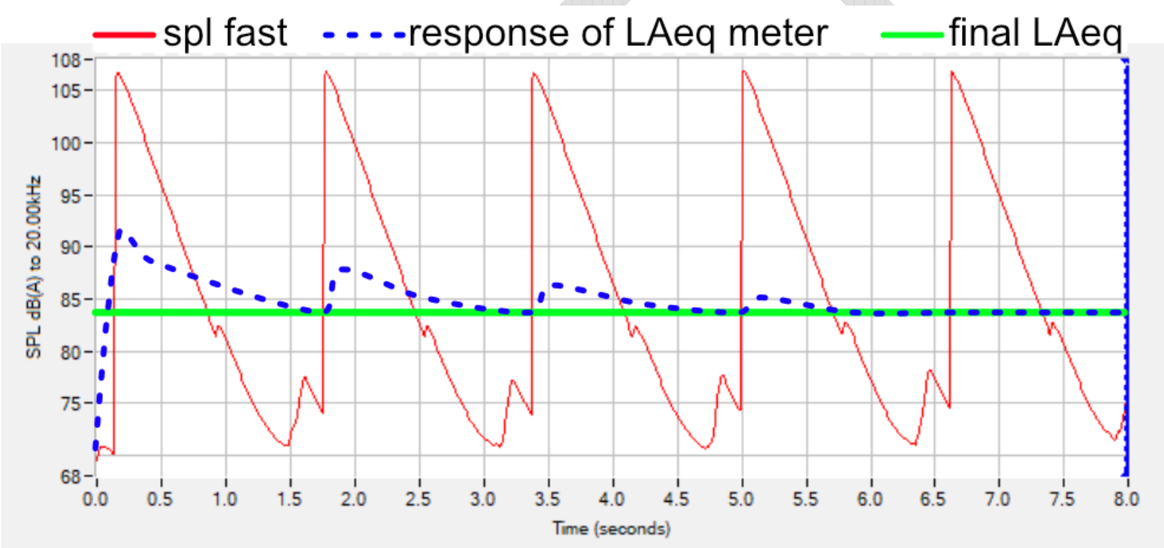
The QR code provides a link to a sound file of a music sample (by permission of Ross Wilson) which, provided it is being replayed through a sound system with good low-frequency performance, illustrates the effect of the "A" weighting filter. It removes the bass from the music. The first sample on the sound file is unfiltered (Linear or Z weighted) whilst the second is "A" weighted.

Although we measure noise using the A-weighted scale, this can create an issue when assessing environmental noise as it progressively attenuates low frequency sound as shown in Figure 5 (i.e. we can't hear low frequency noise as well as the mid-high frequency noise). This can lead to an underestimation of the presence and impact of lower frequency noise.

L_{Aeq}

This is the "A" weighted equivalent continuous noise level. The meter converts a varying noise level into a steady noise level with the same energy content as shown in Figure 6. The L_{Aeq} of the highly impulsive sound is 84dB(A) i.e. the varying sound contains the same energy as a steady sound of 84dB(A).

Figure 6. L_{Aeq} Noise Representation

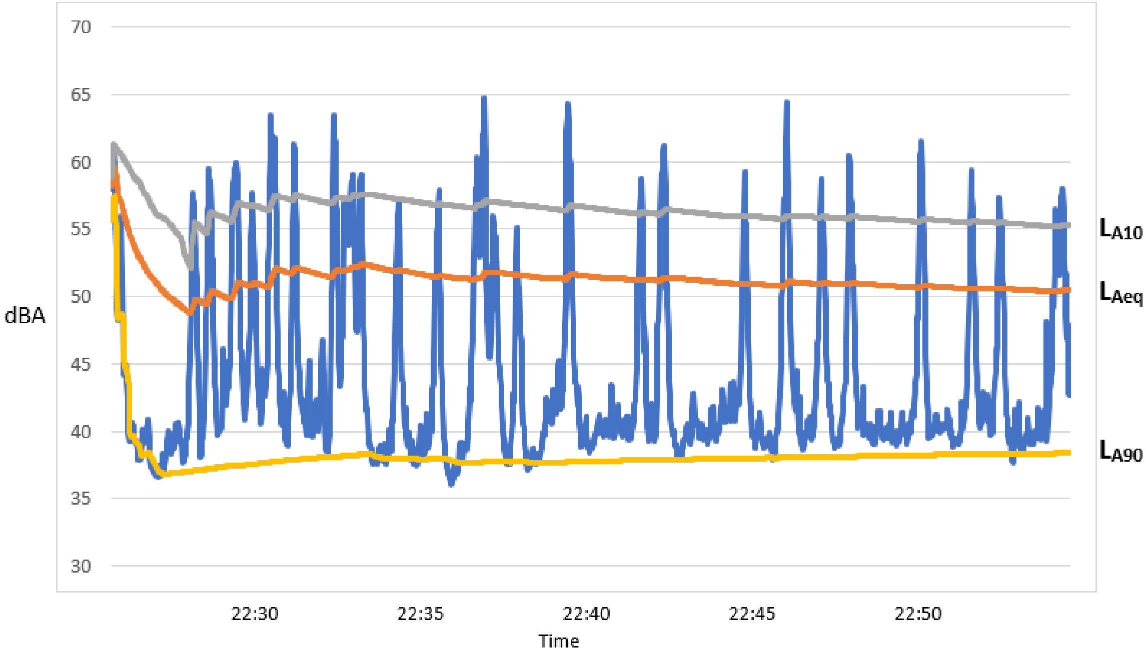


L_{A90} and L_{A10}

These are statistical "A" weighted noise parameters, completely unrelated to the L_{Aeq}. L_{A90} is used to assess the continuous steady background noise by measuring the noise level that is exceeded for 90% of the time. The L_{A10} is a measurement of the variability of the sound, it is the noise level that is exceeded for only 10% of the time. In a quiet street, the L_{A90} will measure the steady hum from a distant motorway and will ignore short term events such as occasional passing cars whereas the L_{A10} will ignore the steady noise and instead will just take into account the passing cars.

For continuous steady noise, both values (and the L_{Aeq}) will be close together. The more variable the noise environment, the greater the difference between the two values. Figure 7 illustrates the principles, showing a 30-minute noise reading where the L_{Aeq} is 52dBA, the L_{A90} is 37dBA and the L_{A10} is 55dBA.

Figure 7. L_{A90} & L_{A10} Noise Representation



Frequency Analysis

Sound signatures can be described in terms of frequency content. In order to investigate the frequency content of the noise in more detail it is necessary to divide the frequency range into bands and measure the sound pressure level in each band. Examples of different frequencies are provided if you scan the following QR codes. Note that the low frequency 100Hz sound is barely audible (and may not be audible to some), whereas the 1kHz and 4kHz sounds are clearly audible in the mid and high frequency ranges.

100Hz **1kHz** **4kHz**

There are 3 types of frequency analysis performed on un-weighted dB(Z) noise measurements:

1/1 Octave Bands: This is low frequency resolution that provides the basic "shape" of the sound signature i.e. the relative levels of sound in each frequency band. For example, the 1kHz octave band sums the noise energy from 707Hz to 1414Hz. This works well for assessing broadband noise with no tonal content. It is not used for environmental noise assessment.

1/3 Octave Bands: These provide a slightly higher frequency resolution by splitting each octave band into three. For example, the 1kHz third-octave band sums the noise energy from 891Hz to 1122Hz. The 1/1 octave and 1/3 octave bands are shown in Table 1.

Narrow Band: This provides very high resolution of the frequencies present in the sound and accurately reflects the subjective impression of sounds. Consequently, it is the recommended approach to evaluate tonal content in noise, particularly when there is difficulty in identifying the tonal noise source by 1/3 octave means.

Figure 8 provides an overlay of the three types of frequency analysis for the same sound.

Figure 8. 1/1/, 1/3 and Narrow Band Frequency Analysis

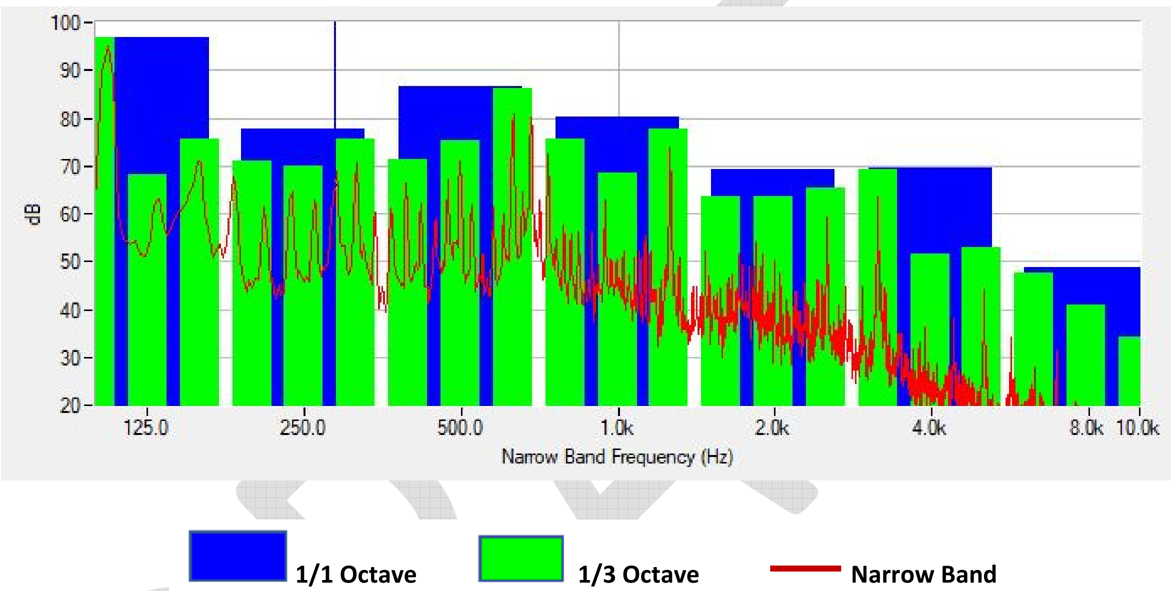


Table 1. Octave Band Frequencies

Octave Bands			1/3 Octave Bands		
Lower Band Limit *(Hz)*	Center Frequency *(Hz)*	Upper Band Limit *(Hz)*	Lower Band Limit *(Hz)*	Center Frequency *(Hz)*	Upper Band Limit *(Hz)*
			11.2	**12.5**	14.1
11	**16**	22	14.1	**16**	17.8
			17.8	**20**	22.4
			22.4	**25**	28.2
22	**31.5**	44	28.2	**31.5**	35.5
			35.5	**40**	44.7
			44.7	**50**	56.2
44	**63**	88	56.2	**63**	70.8
			70.8	**80**	89.1
			89.1	**100**	112
88	**125**	177	112	**125**	141
			141	**160**	178
			178	**200**	224
177	**250**	355	224	**250**	282
			282	**315**	355
			355	**400**	447
355	**500**	710	447	**500**	562
			562	**630**	708
			708	**800**	891
710	**1000**	1420	891	**1000**	1122
			1122	**1250**	1413
			1413	**1600**	1778
1420	**2000**	2840	1778	**2000**	2239
			2239	**2500**	2818
			2818	**3150**	3548
2840	**4000**	2680	3548	**4000**	4467
			4467	**5000**	5623
			5623	**6300**	7079
5680	**8000**	11360	7079	**8000**	8913
			8913	**10000**	11220
			11220	**12500**	14130
11360	**16000**	22720	14130	**16000**	17780
			17780	**20000**	22390

Tonal Noise

People are particularly sensitive to tonal noise (hum, whine, throb, drone etc) where noise energy is concentrated at particular frequencies. The peaks in the red narrow band analysis plot in Figure 8 are tones. Narrow band analysis not only proves the presence of tones, it also identifies the precise frequency of each tone, so it is an indispensable tool to identify tonal noise sources.

Low Frequency Noise

The defined range of low frequency sound varies, depending on the standard / guidance being followed, but for the purposes of this document, sound in the frequency range of c10Hz up to 200Hz can be regarded as "low frequency". The lower the frequency of the noise, the less a given level will contribute to the overall dB(A). Consequently, dB(A) is not a good parameter to use when assessing low frequency sound. In addition, low frequency sound has a long wavelength and is therefore much less directional than higher frequency sound. This can make identifying the source much more difficult (unless there is tonal content), particularly if the source and receiver are some distance from each other.

An additional complication is that conventional techniques to control noise, such as barriers and silencers, are not very effective at low frequencies due to the long wavelength of sound, which can travel over and around a barrier, regardless of distance from the source. The importance of assessing the frequency of sound in barrier design is discussed further in section 13.7.

Impulsive Noise

Impulsive noise is sound characterized by brief bursts of sound pressure at a level which is significantly higher than the background, as shown earlier in Figure 6. Impulsive sound is sound with a sudden onset. "Sudden" is based on an auditive judgement, which is expressed in terms of physical measurements as specified in ISO/PAS 1996-3:2022.

Adding decibels

A decibel is a logarithmic unit, so 10 decibels is equivalent to 10 times more power / amplitude than 0 decibels. To get the overall sound level in dB for a variety of noise sources, use the following formula:

SPL = 10*log(10^(L1/10) + 10^(L2/10) … + 10^(Ln/10))

In this situation the L1 and L2 represent the dB Level 1 and dB Level 2. If you had a speaker playing a sound at 50dB and you added another speaker playing a sound at 50dB, the overall sound pressure level would be:

SPL = 10*log(10^(50/10) + 10^(50/10)) = 53dB

As a rule of thumb, when two decibel levels are equal or within 1 dB of each other, their sum is 3 dB higher than the higher individual level. e.g. 89 dBA + 89 dBA = 92 dBA

If you have a number of noise levels that you need to add, use a scientific calculator, an excel spreadsheet with calculations built in or an online calculator to get the overall sound pressure level.

4.0 COMPETENT PERSON

A competent person is someone who can demonstrate sufficient technical knowledge, experience and skill appropriate to the nature of the work to be undertaken. While no one training course exists in Ireland or internationally that provide the technical knowledge required to be considered "competent" at environmental noise measurements, competent persons in the acoustic field will generally come from engineering or scientific backgrounds, and have specific acoustics knowledge gained at certificate, diploma, degree, master's or doctorate level. Having the technical knowledge is only part of the overall picture, as a competent person requires experience gained on the job as well as skill to collect, analyse and interpret noise data. It is important to note that a person may have knowledge and experience of environmental noise measurements, but this may not be sufficient for analysing and interpreting noise data, especially where specific acoustic features e.g. tonal/impulsive noise is present.

To be considered a competent person for environmental noise survey work, an individual must be able to demonstrate proficiency in terms of (a) Qualifications (b) Training and (c) Experience (see examples of each in Table 2). Note that in certain cases, (e.g. sites with a large number of monitoring locations), it may be acceptable for basic survey work to be conducted by staff who may not yet possess all the competencies listed in Table 2, once they are under the supervision of a senior colleague who is competent. A clear statement of proficiencies for each member of the monitoring and assessment team in each category should be provided in a noise assessment report.

The EPA require that all surveys shall be supervised, and reports reviewed, by senior personnel with relevant acoustic qualifications, training and at least 3 years of recent, regular and relevant experience. Investigations into issues involving tonal, impulsive or low frequency noise shall be led by senior personnel with experience in those specific issues.

Table 2. Examples of Competency in Environmental Noise Assessment

(A) Qualification

- **A recognised acoustic qualification.**
- **Membership of a professional or trade body (e.g. the Institute of Acoustics, the Association of Acoustic Consultants of Ireland, etc.).**

(B) Training

- **Comprehension of the requirements of relevant acoustic standards.**
- **Knowledge of relevant noise indices.**
- **An ability to perform necessary acoustic calculations where appropriate.**
- **Familiarity with acoustic software such as that used for the analysis of survey data and noise modelling.**
- **A clear understanding of the licensing obligations with regard to noise.**
- **Demonstration of participation in Continual Professional Development in acoustics.**

(C) Experience

- **Experience in acoustic monitoring, noise survey equipment and technical reporting.**
- **Practical knowledge and experience of spectrum analysis, octave band, 1/3 octave band and narrow band analysis and the ability to assess tonal and impulsive elements.**
- **An ability to analyse, interpret and explain results.**
- **An ability to recognise when more specialist expertise may be needed, e.g. engineering noise control expertise or expertise re NANR45 for low frequency noise.**

5.0 ENVIRONMENTAL NOISE CRITERIA

When preparing an IE/IPC or Waste Licence application, it is considered that one of the most important aspects of the noise section should relate to the proposal and justification of suitable criteria noise levels (noise limits) that will apply to the operation in question. This section outlines the pertinent factors that should be considered and provides a simple scoping process to arrive at suitable noise criteria. It is considered that the guidance outlined here will be appropriate for the majority of situations; however, in certain instances an alternative approach may be considered. In these cases, the Agency will consider each application on its own merits following review of any detailed acoustic assessments and associated discussion put forward.

5.1 Noise Conditions in EPA Licences

The EPA sets conditions relating to noise and imposes noise limits on scheduled industrial activities. The application of conditions and limits should seek to minimise the amount of noise to which people in Noise Sensitive Locations (NSLs) are exposed. Examples of such locations include dwellings, hospitals, schools, places of worship and areas of high amenity. A more complete definition of the term NSL is often given in licences and a definition is also given in Appendix 1.

Typical noise conditions state;

- Noise from the installation shall not give rise to sound pressure levels measured at any Noise Sensitive Location which exceed the limit value(s).
- There shall be no clearly audible tonal component or impulsive component in the noise emission from the activity at any NSL.
- The licensee shall carry out a noise survey of the site operations annually. The survey programme shall be undertaken in accordance with the methodology specified in the 'Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4) published by the Agency.

Some licences may also include conditions in relation to the requirement for preparing, maintaining and implement a noise management plan, for example;

- The licensee shall prepare, maintain and implement, to the satisfaction of the Agency, a Noise Management Plan.
- The plan shall outline noise reduction and abatement measures.
- The plan to reduce noise emissions should include the following mitigation measure(s): abatement and enclosure of operations, processes and equipment giving rise to exceedances of noise limit values measured at noise sensitive locations.
- The plan shall be prepared in accordance with the Agency's Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4).
- The plan shall be reviewed and updated annually.

Further details on the requirements of Noise Management Planning is provided in Section 11.

When an EPA licence includes conditions relating to noise emissions, this would normally entail specified numerical noise limits which are not to be exceeded. These limits may apply to individual sources of noise on the site itself, at the boundary of the site or at the nearest NSL. The setting of noise limits at any or all of these locations may be required, and the assignment of such limits will be decided during the licensing process for the facility. During all periods, rigorous efforts should be made to avoid clearly audible tones and impulsive noise at all sensitive locations. If tonal and impulsive noise is present, appropriate penalties are to be applied to day and evening time readings; no clearly audible tonal or impulsive characteristics should be present at night time.

All reasonably practicable measures should be adopted at licensed facilities to minimise the noise impact of the activity and BAT should be used in the selection and implementation of appropriate noise mitigation measures and controls. While BAT must be applied on a case by case basis, the noise attributable solely to on-site activities, expressed as a free-field value at any NSL, should not generally exceed the values in Figure 9.

Figure 9. Typical Noise Limits

The $L_{Ar,T}$ day and evening reading is the **rated noise level**, equal to the site specific sound level L_{Aeq} (refer to section 7.8) at the assessment location over a specified measurement time interval (T), **plus the specified adjustments for tonal character and/or impulsiveness of the sound**. Further information on penalties to be applied is provided in the following sections.

If tonal (refer to section 8.3) and/or impulsive (refer to section 10.3) characteristics are clearly audible at night, then this alone is a non-compliance with the licence, regardless of the overall noise level.

In instances where an older licence is in place, the noise criteria stated in the licence still stand. If these licences come under review at a future date, consideration will be given on a case-by case basis in relation to changing from the previous approach (i.e. daytime and night-time noise limits) to the approach outlined in this guidance note (i.e. daytime, evening and night-time limits).

EPA licences require that, in addition to the licence limit values and conditions, the noise from the licensed facility shall not be so loud, so continuous, so repeated, of such duration or pitch, and should not occur at such times, as to give reasonable grounds for annoyance. Detailed assessment is required for sites where this is the case, as explained in this guidance.

In particularly Quiet Areas, such as remote or rural settings, where the background noise levels are very low, lower noise limits may be more appropriate and this may be reflected in more stringent licence limits being set. Further guidance on the assessment of Quiet Areas and areas of low background noise is outlined in the following sections. In the context of this document, these are two distinct and different areas of concern.

5.2 Pertinent Factors in Determining Noise Controls and Limits

The primary objective of this guidance note is to provide some practical information and advice in respect of those activities that are listed in the First Schedule to the Environmental Protection Agency Acts of 1992 as amended and the Third and Fourth Schedules to the Waste Management Acts of 1996 as amended. While the guidance note deals in general terms with the approach to be taken in the assessment and control of noise, it does not purport to be a statement of BAT with respect to the noise emissions from these activities, as outlined in Section 2.4.

The generation of excessive noise in the community can have undesirable effects on the population. Noise is liable to give rise to complaints whenever the level exceeds the pre-existing level by a certain margin, whenever it exceeds certain absolute values or whenever it contains acoustic characteristics e.g. tonal/impulsive or other characteristics. The application of controls and limits should seek to minimise the amount of noise to which people in NSLs are exposed.

5.3 Quiet Area Screening & Low Background Noise

This section of the guidance outlines how a Quiet Area is assessed and how an area of low background noise is assessed, both of which are distinct and different areas of concern in the context of this document.

5.3.1 Quiet Area Screening of the Development Location

According to the Agency publication *Environmental Quality Objectives - Noise in Quiet Areas*, a 'Quiet Area' in open countryside is "*undisturbed by noise from traffic, industry or recreational activities*". In addition, the documents states that 'the noise from anthropogenic (human) sources should not be clearly audible at any point within Quiet Areas'.

It should be noted that, in a Quiet Area, it does not necessarily follow that levels of noise within the area will be low. The noise levels in a quiet area will typically have little, if any, contribution from manmade (i.e. anthropogenic) noise sources such as road, rail or industrial sources. However, the noise levels may be elevated due to the natural noises that form the soundscape of the area in question. Some rural areas may not fall within the definition of a "Quiet Area" during the day, but may meet the criteria at night time, so the objective would be to preserve the night time noise levels in this instance.

In reality, if a Quiet Area in open countryside exists, then development options will be limited as the noise limit criteria are extremely low; the objectives are to preserve these areas where they exist and ensure that new activity or development does not increase the existing background noise levels.

A screening process is undertaken to assess if a development is to be located in a Quiet Area, as shown in Table 3. If all answers to the criteria are 'Yes', then further assessment is required to determine the background noise in the area and assess if more stringent noise limits are appropriate to preserve and maintain the area, to avoid harmful effects of environmental noise.

Further details on the noise assessment required if a site is in a Quiet Area is provided in Section 5.5 and Appendix 2.

If one or more answers in the Table 3 is no, then the site is not in a Quiet Area and a further assessment should be conducted to see if the development is in an area of Low Background Noise, as outlined in Section 5.3.2.

Table 3. Quiet Area Screening Criteria

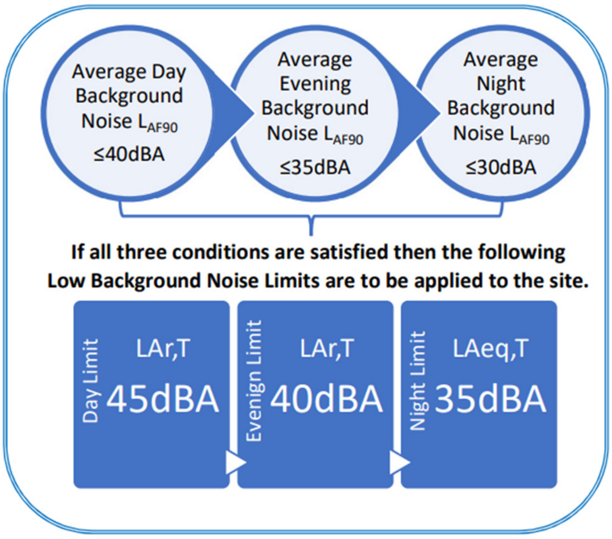
Is your site at Least	From	With a Population of	Yes/No
3km	Urban Area	>1,000 people	
10km	Urban Area	> 5,000 people	
15km	Urban Area	> 10,000 people	
3km	Local Industry Noise sources considered industrial in nature e.g. grain drying facilities, creameries, small factories etc.		
10km	Major Industry Centre		
5km	National Primary Route		
7.5km	Motorway or Dual Carriageway		

5.3.2 Low Background Noise Assessment

If the proposed development location is not in a Quiet Area, it also needs to be assessed to see if it is an area of Low Background Noise. This is undertaken by comparing the background (L_{AF90}) sound levels during the day, evening and night (taken from a baseline noise- survey), to the criteria outlined in Figure 10. Following this method, if **all three** criteria are met, then the area is considered an area of Low Background Noise and the lower noise limits specified are applicable.

The average background noise level for a specific period may be represented, for the purposes of this assessment, as the arithmetic average of the measured L_{AF90} noise level during the relevant period. Each measurement location will typically have a different average background noise level, so the measurement results from each location will have to be compared to the criteria. There may be occasions when, for the same development, some measurement locations are defined as areas of low background noise and some are not. The determination of appropriate noise criteria should be considered for each measurement location in isolation.

Figure 10. Criteria for Low Background Noise Area



5.4 Strategic Noise Maps

A strategic noise map is a graphical representation of the predicted situation with regards to noise in a particular area and from particular noise sources, with different colours representing different noise levels in decibels - dB(A). Under the Environmental Noise Regulations, strategic noise maps are to be prepared every 5 years from the following sources:

- Major roads (>3 million vehicle movements per year)
- Major rail (>30,000 rail passages per year)
- Major airports (>50,000 air movements per year)
- Major cities (i.e. agglomerations >100,000 inhabitants), which include Dublin, Cork and Limerick

It should be noted that the main focus of noise maps is the strategic management of environmental noise, based upon a notional annual average day. They should not be seen as representing what may be measured directly at any location within the map.

Following the preparation of the noise maps, Noise Action plans are developed by Local Authorities in order to manage noise issues and effects. Noise Action Plans are intended for defining Important Areas (IAs) where the L_{den} is ≥53dB and L_{night} is ≥45dB (in line with WHO 2018 guidelines[2]). L_{den} is the day-evening-night noise indicator and represents the noise indicator for overall annoyance. It is 'weighted' to account for extra annoyance in the evening and night periods.

Most Important Areas (MIAs), i.e. Important Areas with the largest concentration of people highly annoyed due to noise, are to be defined in Noise Action Plans along with Priority

[2] Environmental noise guidelines for the European Region. Copenhagen: WHO Regional Office for Europe; 2018

Important Areas (PIAs) i.e. those where the Local Authority commits to undertaking an assessment of noise mitigation for identified PIAs. Noise Action Plans should also identify areas below the recommended level for the purposes of preservation, to help identify Quiet Areas i.e. a space that is not affected by noise from transport, industrial activities or recreational noise.

Within the three agglomerations of Dublin, Cork and Limerick, industrial noise from IE / IPC and Waste licensed sites falls within the scope of the Environmental Noise Regulations. The strategic noise maps and noise action plans for the agglomerations need to include the assessment and control of noise from licensed industrial sites if the noise emitted by such sites exceeds the 53dB L_{den} and 45dB L_{night} thresholds. If this is the case, then the Action Planning Authority for the Noise Action Plan will discuss the licence conditions in place and the current approach to noise management at the facility, with the Agency. Outside of these three agglomerations industrial noise does not fall within the scope of the Environmental Noise Regulations.

It is important to note that the Environmental Noise Regulations specifically set out a new process by which noise from licensed industrial sites within agglomerations is to be mapped, published and strategically managed. The Environmental Noise Regulations do not, however, introduce a new mechanism by which the aims of the noise action plans may be delivered. For example, should a licensed industry within an agglomeration have a noise emission above the reporting thresholds, any proposed reduction in noise emission within the noise action plan drawn up by the local authorities would be facilitated via amendment of the licensing conditions relating to noise, which are drawn up by the Agency.

It can be seen that the IE/IPC & Waste regulations set out a licensing program by which noise from industrial sites may be controlled as necessary, whilst the Environmental Noise Regulations set out a strategic management framework that operates above this and which involves the local authorities and public as stakeholders. The strategic noise maps publish information on industrial noise emissions within agglomerations on a consistent basis, whilst the noise action plans enable the local authorities and public to be involved in setting long-term aims and objectives for noise control.

5.5 Setting Appropriate Noise Criteria / Limits

For some licensed sites, higher limit values may be set at the boundary than at NSLs to reflect the relative proximity to the source of noise on-site and the proximity of the NSL to the site. The boundary of a plant may offer more practical and easier access for subsequent noise monitoring. Typically, limits are set at the boundary for industrial estates and at the nearest NSLs and receptors for 'one off' developments and particularly for green field sites.

In instances where an industrial site is applying for an Agency licence and is proposing the implementation of higher noise levels at various points on the boundary of the site, the application should be supported by a sufficiently detailed noise assessment demonstrating that such limits at the boundary will not have a detrimental effect on any NSL beyond the site boundary. Note that the use of boundary measurements must take into consideration whether the proposed measurement locations are screened from significant site noise sources. For example, a boundary measurement 10m from the side of a two-storey building where there are noisy extract fans at roof level would not be acceptable as a monitoring location, due to the screening effect of the building.

Alternatively, noise limits may be set on individual sources of noise, taking cognisance of the target limit values to be achieved either at the boundary or nearest NSL. This approach would normally only be considered if there were difficulties in attaining reliable noise data at the site boundary or at NSLs. In such circumstances recourse may also be made to the use of noise modelling techniques.

Restrictions on times of operation may be imposed for all or part of the plant, however, this aspect needs to be balanced with the economic and/or logistical impact on the operation of the plant.

In some instances, licensed sites will have certain items of emergency equipment (e.g. standby generators) that will only operate in urgent situations (e.g. grid power failure). Depending upon the context, it may be deemed permissible for such items of equipment to give rise to exceedances in the noise criteria/limits during limited testing and emergency operation only. If such equipment is in regular use for any purposes other than intermittent testing, it is subject to the standard limit values specified in the licence.

The following methodology is recommended for the selection of appropriate noise criteria for licensed operations. This methodology should be followed for **all licence applications**. The proposed methodology gives specific guidance on how to deal with areas with relatively low background noise levels. This methodology only applies to new licence applications as it is considered impractical to attempt to retrospectively apply the approach to existing licensed facilities, although the Agency may stipulate that this approach is to be followed when a licence comes under review. The following sections outline the steps to be followed in order to derive appropriate noise criteria.

Step 1. – Quiet Area Screening

Quiet Area Screening should be conducted at the development location, as outlined in Section 5.3.1. Depending on the outcome of this screening, there are different requirements for the environmental noise survey to be undertaken as part of a new licence application.

Step 2A. – Baseline Noise Survey when site IS in a Quiet Area

If the screening process in Step 1 identifies that the site is in a Quiet Area then it is necessary to conduct an extensive long-term background noise survey, at a number of locations, over an extended period, under a range of weather conditions, in order to establish existing noise levels. This should involve unattended noise measurement at a minimum of two locations for a period of at least two weeks at each location (measurements should ideally be concurrent).

A sufficient number of locations should be monitored in order that a robust picture of all NSLs within the vicinity of a proposed development is obtained and assessed.

Weather monitoring should also be conducted at a location representative of the noise survey location. General guidance on how the noise survey should be carried out is outlined in Section 7.

The results of the survey should be analysed to establish the average background noise levels (in terms of L_{AF90}) during daytime, evening and night-time periods. The resultant noise criterion applicable to the licensed facility (in terms of either $L_{Ar,T}$ or $L_{Aeq,T}$) is then derived by subtracting 10dB from the average background noise level during each day, evening and night time period.

Further information on Quiet Area Screening equipment set-up and data analysis is provided in Appendix 2.

Step 2B. – Baseline Noise Survey when site is NOT in a Quiet Area

If the screening process in Step 1 does not identify a quiet area, then a series of attended noise measurement surveys at the nearest NSLs to the proposed development are to be conducted over day, evening and night-time periods at a minimum. The noise survey guidance outlined in Section 7 will apply.

A template for the recording of a baseline attended noise survey is presented in Appendix 3. The frequency and duration of monitoring shall be determined and justified by the competent person depending on the site circumstances, in order to obtain robust data to ascertain noise levels at the noise sensitive locations. Long term unattended noise monitoring (with audio recording) may also be appropriate to account for site specific variability and this will also allow for the calculation of L_{den} and L_{night} for sites within agglomerations.

Step 3. – Screen Areas for Low Background Noise

For all areas screened out in Step 1 i.e. they do not meet the criteria for a Quiet Area, the existing background noise levels (L_{AF90}) obtained from the baseline attended noise survey in Step 2B should be compared to the criteria outlined in Figure 10 and if all three criteria are met, then the area is considered an area of Low Background Noise and the lower noise limits specified are applicable.

The average background noise level for a specific period may be represented by the arithmetic average of the measured L_{AF90} noise level during the relevant period. All noise monitoring results and derived averages should be rounded to the nearest whole integer, with 0.5 being rounded up. Each measurement location will typically have a different average background noise level, so the measurement results from each location will have to be compared to the criteria above. There may be occasions when, for the same development, some measurement locations are defined as areas of low background noise and some are not. The determination of appropriate noise criteria should be considered for each measurement location in isolation. Further details are provided in Appendix 3.

Step 4. – Determine Appropriate Noise Criteria

The noise limit criteria to be applied depending on the outcome of Steps 1-3 are provided in Table 4. A flowchart is also provided in Figure 11.

Table 4. Recommended Noise Limit Criteria

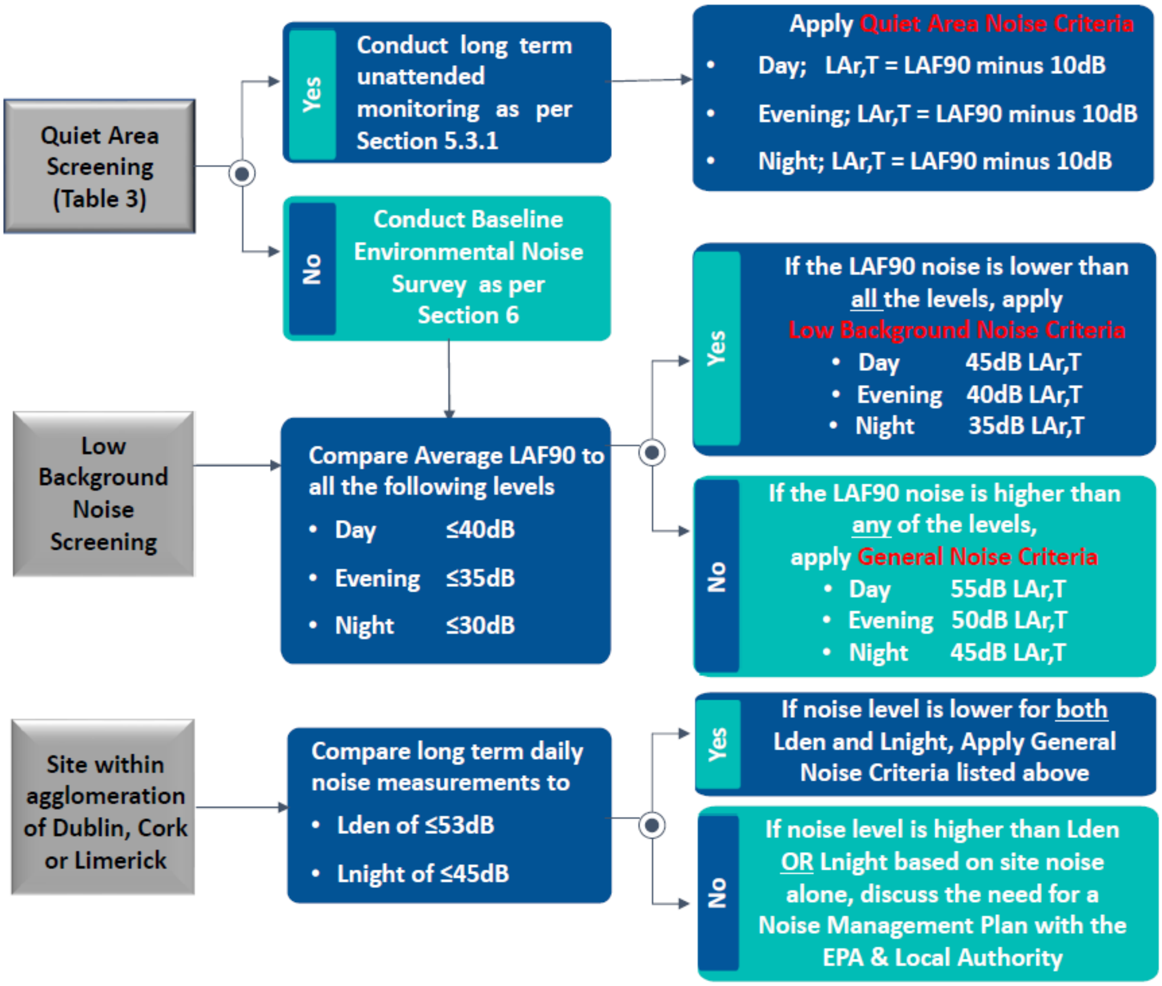
Scenario	Daytime Noise dBA $L_{Ar,T}$ (07:00 to 19:00)	Evening time Noise dBA $L_{Ar,T}$ (19:00 to 23:00)	Night time Noise dBA L_{Aeq} (23:00 to 07:00)
Quiet Area	Noise from the licensed site to be at least 10dB below the average daytime background noise level measured during the baseline noise survey. i.e. L_{AF90} -10dB	Noise from the licensed site to be at least 10dB below the average evening background noise level measured during the baseline noise survey. i.e. L_{AF90} -10dB	Noise from the licensed site to be at least 10dB below the average night-time background noise level measured during the baseline noise survey i.e. L_{AF90} -10dB
Areas of Low Background Noise	45 dB	40 dB	35 dB
All Other Areas	55 dB	50 dB	45 dB

Note the above limit values are recommended for new licence applications for scheduled activities and they should be used with caution for other industrial settings (proposed or existing). Regard should be made to the existing background noise in the area before new noise sources are added. In addition, the acoustic characteristics of the noise (e.g. tonal, low frequency, impulsive or intermittent) are important factors to consider in the assessment of noise from a proposed site in conjunction with the overall broadband noise level.

Step 5. – Sites within Agglomeration of Dublin, Cork or Limerick

For sites within the agglomerations of Dublin, Cork or Limerick it is necessary to review the relevant Noise Action Plan with the Planning Authority to determine the L_{den} and L_{night} Noise Action Plan limits applicable to the development location. The site may be required to assess if it will impact on the noise limits in place and devise a Noise Management Plan if this is the case.

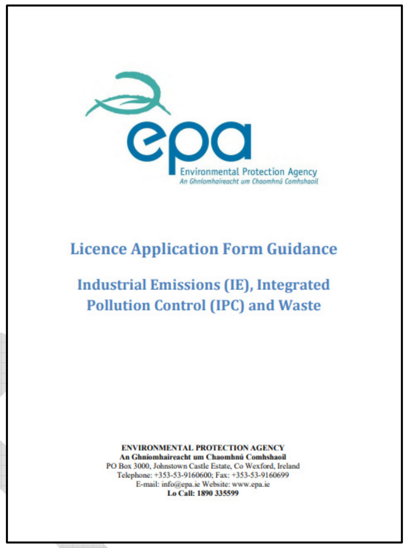
Figure 11. Flow Chart for the identification of Appropriate Noise Criteria



Note - Day (07:00-19:00); Evening (19:00-23:00) & Night (23:00-07:00) applies in all cases above.

6.0 NOISE ASSESSMENT FOR LICENCE APPLICATIONS

An important aspect of the licensing process relates to the provision of the initial noise impact assessment of the proposed activity on the existing environment. The approach in determining the appropriate nose criteria applicable to a site in support of a licence application has been outlined in Section 5.



Environmental Protection Agency
An Ghníomhaireacht um Chaomhnú Comhshaoil

Licence Application Form Guidance

Industrial Emissions (IE), Integrated Pollution Control (IPC) and Waste

ENVIRONMENTAL PROTECTION AGENCY
An Ghníomhaireacht um Chaomhnú Comhshaoil
PO Box 3000, Johnstown Castle Estate, Co Wexford, Ireland
Telephone: +353-53-9160600; Fax: +353-53-9160699
E-mail: info@epa.ie Website: www.epa.ie
Lo Call: 1890 335599

The following section provides further guidance, outlined in four stages, in relation to the level of information and assessment required, in order to allow the Agency to complete a robust and in-depth review of any potential noise impact associated with a facility.

As part of the IE/IPC/Waste Licence application the applicant must provide information relating to:

- Noise emissions from the facility;
- An appropriately detailed assessment of the impact of those emissions on NSLs, and;
- The noise control measures that will be implemented/installed (where necessary).

Each application will vary, with more detailed and in-depth acoustic assessments required for certain (typically larger) facilities. This is to say that the higher the potential for a site to cause annoyance or other environmental impact, the more detail that is required, including detailed and specific recommendations on proposed noise control measures.

6.1 Stage 1 – Baseline Noise Survey/Monitoring Locations

Section 5 of this document outlines how baseline noise surveys should be undertaken as part of a licence application. Appendices 2 & 3 illustrate how the noise data from these surveys should be reviewed and presented to the Agency. The following paragraphs present some guidance on how noise measurement locations should be identified.

To determine the noise measurement positions for a licence application or other purpose for a new/greenfield site or existing site these should include those positions which will be most affected by the facility's emissions. The following process is recommended:

- An initial desktop risk assessment to identify NSLs followed by a site inspection to assess the site, the noise sources and intervening ground between the site and the NSLs.
- NSLs should be marked onto relevant drawings and the proposed development overlaid, and;
- At this stage some preliminary noise calculations should be undertaken with a view to identifying locations where noise monitoring should be focused (e.g. if site orientation

indicates that noise emissions will be higher to the south of a site, additional noise monitoring locations may be chosen at NSLs in this vicinity).

Given that the locations selected at this stage will influence the noise measurement locations that will be defined in any licence issued to an operator, appropriate positions should be selected with reference to the definition of 'NSL'. The choice of measurement location is often not straightforward. Generally, the main issue to be addressed is quantifying the noise level experienced by the affected people. This usually implies measurement outside the building, most representative of the elevation at the building, where people are likely to be affected by noise.

Ongoing access will typically be required to the noise measurement locations selected in these instances. Therefore, issues of ongoing access arrangements (e.g. if the measurement location is on private property) should be given adequate consideration in the selection of noise measurement locations.

The noise criteria outlined in this document are **'free-field'** levels, i.e. levels where the influence of reflections has been minimised. Whenever possible, the noise measurements should therefore be carried out at least 3.5 metres from any reflecting structure other than the ground. The preferred height for the microphone is 1.2 to 1.5 metres above ground level.

In certain instances, it may be more appropriate to identify boundary locations in relation to ongoing or permanent monitoring locations (e.g. in terms of the Annual Noise Survey). Where boundary locations are being proposed, careful consideration should be given to the following issues:

- The boundary location may be in an '**acoustic shadow'**, for example, if the principal noise source on a site is a set of extract fans on the roof of the facility, a location on the boundary may benefit from acoustic screening provided by the site buildings themselves. The resultant measured levels would not be representative of noise emissions from the site;
- It may be difficult to achieve a free–field measurement location (that is, away from building reflections), in which case any necessary corrections as a result of such reflections should be applied, and;
- In the case of large installations, a boundary measurement location may not be representative of the sound levels at the receptor.

If a boundary location is adopted as an ongoing position for annual noise measurement, careful consideration should be given to the noise levels obtained. If NSLs are close to the boundary the situation is straightforward and the measured levels can be easily interpreted to demonstrate compliance with relevant noise criteria. However, if the nearest NSLs are somewhat removed from the boundary measurement location the expected noise levels should be extrapolated to the nearest NSLs. The extrapolation will not be as accurate as measurement and therefore, it is preferable to enforce noise criteria by measurement at NSLs.

It may be appropriate to define measurement locations that are neither in the immediate vicinity of the nearest NSL nor on the site boundary, in order to provide results that are more straightforward to interpret and/or extrapolate.

6.2 Stage 2 – Derivation of Noise Criteria

Based on the results of the baseline noise survey, the relevant noise criteria for the site should be derived as per the guidance contained in Section 5.5 of this document.

6.3 Stage 3 – Assessment of Noise Impact

For a new licence application/greenfield sites or a licence review, the assessment of noise impact is an important consideration to determine if the relevant noise criteria can be adhered to and to assist in identifying relevant noise control measures required to comply with the appropriate noise criteria if necessary.

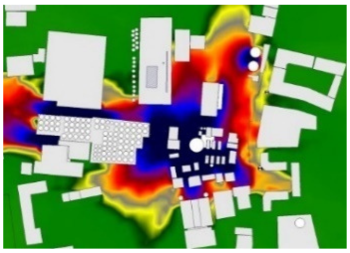
In some circumstances where the noise impact externally is likely to be limited (low noise sources and no tonal/impulsive or other sound characteristics), the calculation of sound propagation with distance and/or comparison of baseline noise measurement with noise criteria or limits data may be sufficient to assess the noise impact at relevant noise sensitive locations. ISO 9613-2 can be used by the competent person to calculate the propagation of noise outdoors, to predict the level of environmental noise at a distance from a variety of sources while taking into account many factors including barriers, ground absorption and attenuation.

In more complex settings, assessment of noise impact may be undertaken by noise modelling, which is typically used on large developments with multiple noise sources, but it is also used on smaller sites. Where one or two noise sources are to be added to a development, the assessment of the significance of noise impact may be assessed using BS 4142:2014 +A1:2019, *Methods for rating and assessing industrial and commercial sound*.

6.3.1 Noise Modelling

The noise levels expected at site boundaries and NSLs will need to be considered and presented as part of a licence application.

For larger sites and those with a lot of noise-generating plant, the use of a computer-based noise model lends itself to a comprehensive analysis of noise propagation. It also aids the user in identifying the key contributors to off-site noise levels, thereby ensuring that noise control measures are correctly targeted. This applies equally to both proposed and existing sites.



ISO 1996-2, sections 12.1 & 12.2 provides guidance regarding calculation methods used to predict sound at distance using the sound power level, source directivity and location for all relevant noise sources. Guidance on mapping is also provided in this standard.

ISO 9613-2 is the basis for many computer-based noise modelling packages and as a matter of default, is the calculation methodology preferred by the Agency in terms of scheduled activities. Other calculation methods may be used, but their use should be fully justified. A list of national and European prediction methods is given in Annex L of ISO1996-2.

Be aware that it is recommended that modelling consider the frequency and tonal content of noise from sources, not just the overall dB(A). This is particularly applicable to sources that generate significant sound at low frequencies. Also be aware that the effective and accurate use of modelling software requires considerable underlying acoustic expertise.

The following checklist is to be used for the preparation of detailed noise calculations and associated noise assessment in relation to licensed activities.

- **Has a suitable site Noise survey and inspection been completed?**
- **Have the correct NSLs been chosen?**
- **Have the correct details been assigned to the NSLs (e.g. height, exposed façade(s), local screening, line of sight to critical noise sources etc.)?**
- **Have the correct survey periods been chosen to account for time varying, infrequent and ancillary activities?**
- **Has the appropriate level of detail been selected for noise prediction (e.g. simple spreadsheet calculation of overall noise levels for simple site, to detailed octave band calculations for more complex situations).**
- **Have details of dominant frequencies of plant and equipment, from the supplier, been included and considered in the mitigation measures? (e.g. octave band as a minimum and/or one-third octave if available)?**
- **Have recordings of similar equipment/plant in-situ/operation at other locations been assessed (if available)?**
- **Have suitable noise criteria for day, evening and night time periods been derived from the survey data?**
- **Have all significant external noise sources been identified and associated noise data obtained (either through measurement, empirical equations or manufacturers' data)?**
- **Has noise breakout from buildings been considered in appropriate detail (e.g. noise across open doors, louvres, ventilation systems etc.)?**
- **Have the proper considerations for noise source type (i.e. line, point, plane), 'on time' and directivity corrections etc. been applied to the relevant noise sources?**
- **Has appropriate consideration been taken of:**
    - **ground topography between sources and receivers;**
    - **site buildings and intervening structures (e.g. barriers);**
    - **reflections;**
    - **ground absorption;**

  - **temperature and humidity?**
- **Do the final results appear conclusive?**

6.3.2 Assessment of Impact: BS4142

Where a new licence application has a limited number of noise sources or is relatively small in nature, or in a review application where new plant or equipment is being added (prior to its introduction to the site), the assessment of the significance of the impact of particular noise sources can also be undertaken following *BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial* sound.

This standard uses a 'rating level, which is based on a comparison between the sound which is being assessed and the background sound which would exist without it. The rating level is then modified by any corrections for the character of the sound, be that tonal, impulsive, intermittent or other sound characteristics. Typically, the greater this difference, the greater the magnitude of the impact. Where the rating level does not exceed the background sound level, this is an indication that the specific sound source will have a low impact, depending on the context.

According to BS4142, the significance of impact of noise sources depends on "*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."* All these factors need to be considered to assess the significance of the impact of a noise source.

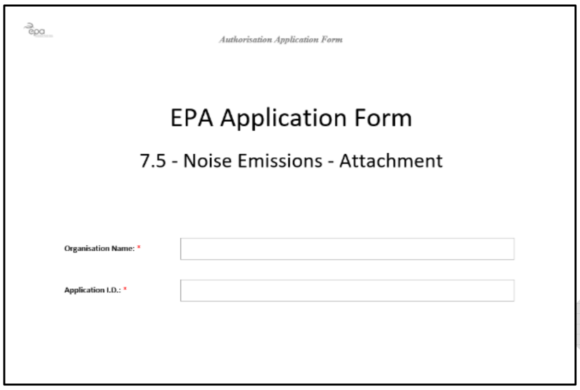
The standard advises that if the noise rating level exceed the background level by around +10 dB or more, this is likely to be an indication of a ***significant adverse impact**,* depending on the context. A difference of around +5dB is likely to be an indication of an *adverse impact,* depending on the context. 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.

The application of BS4142 is to be undertaken by a competent person and the standard advises that the BS4142 report is to contain *a statement of qualifications, competency, professional memberships and experience* directly *relevant to the application of the British Standard of all personnel contributing to the assessment*. The standard provides a detailed procedure for the assessment of significance of the noise sources, with detailed examples for reference purposes, along with information to be reported as part of the assessment. Appendix 5 of this guidance provides an example of a BS4142 assessment for two noise locations and further examples are provided within the standard itself. Note that BS4142 is not applicable to the assessment of low frequency noise.

When the impact of noise from the site is assessed as significant from noise monitoring (for an existing site), by calculation (ISO9613-2 method), by noise modelling (ISO9613-2 method) and/or BS4142 assessment, a noise management plan as outlined in Section 11 will have to be devised to demonstrate how the site will comply with the relevant noise criteria applicable to it, in line with BAT. Preparation of a noise management plan may be required as a condition of an EPA licence and is good practice for all industrial sites.

6.4 Stage 4 – Reporting/Licence Application Form

An application for an IE/IPC or Waste licence or revised licence must be summitted using the EPA online application form via the Environmental Data Exchange Network (EDEN) online portal. Section 7.5 of the licence application relates to Noise and the *Noise Emissions Attachment* needs to be complete and any relevant additional/supporting information uploaded to the online application.



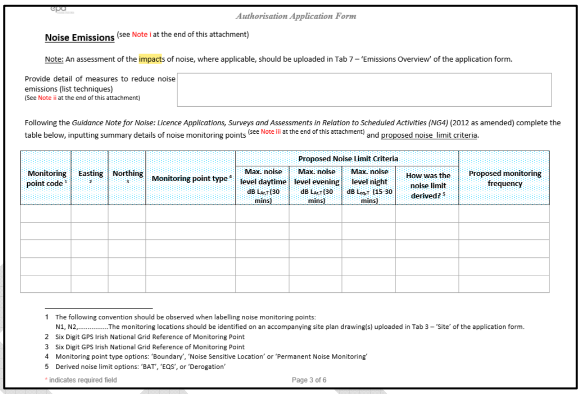
Authorisation Application Form

EPA Application Form

7.5 - Noise Emissions - Attachment

Organisation Name: *

Application I.D.: *



Authorisation Application Form

Noise Emissions (see Note i at the end of this attachment)

Note: An assessment of the impacts of noise, where applicable, should be uploaded in Tab 7 – 'Emissions Overview' of the application form.

Provide detail of measures to reduce noise emissions (list techniques) (See Note ii at the end of this attachment)

Following the *Guidance Note for Noise: Licence Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)* (2012 as amended) complete the table below, inputting summary details of noise monitoring points (see Note iii at the end of this attachment) and proposed noise limit criteria.

Monitoring point code [1]	Easting [2]	Northing [3]	Monitoring point type [4]	Proposed Noise Limit Criteria				Proposed monitoring frequency
				Max. noise level daytime dB $L_{Ar,T}$ (30 mins)	Max. noise level evening dB $L_{Ar,T}$ (30 mins)	Max. noise level night dB $L_{eq,T}$ (15-30 mins)	How was the noise limit derived? [5]	

1 The following convention should be observed when labelling noise monitoring points: N1, N2,................The monitoring locations should be identified on an accompanying site plan drawing(s) uploaded in Tab 3 – 'Site' of the application form.
2 Six Digit GPS Irish National Grid Reference of Monitoring Point
3 Six Digit GPS Irish National Grid Reference of Monitoring Point
4 Monitoring point type options: 'Boundary', 'Noise Sensitive Location' or 'Permanent Noise Monitoring'
5 Derived noise limit options: 'BAT', 'EQS', or 'Derogation'

* indicates required field

Page 3 of 6

The *Noise Emissions* Attachment is to include:

- ✓ Detail of measures to reduce noise emissions (list techniques) (if required);
- ✓ The reference number of the noise monitoring location (N1, N2 etc.);
- ✓ The six-digit Irish National Grid Reference of Monitoring Point (E, N);
- ✓ The monitoring point type i.e. Boundary, Noise Sensitive Location or Permanent Noise Monitoring;
- ✓ The day, evening and night time noise limit criteria applied (as per Section 5);
- ✓ Information on how the noise limit criteria was derived (BAT, EQS, Derogation);
- ✓ The proposed frequency of monitoring;
- ✓ Details as to whether an assessment for tonal and impulsive noise was carried out and whether it is present or absent.

Additional/supporting information to be included in the online application consists of:

1. Baseline Noise Survey Report;
2. Site drawing showing Noise Monitoring Locations (N1, N2 etc);
3. Noise Modelling Report and/or BS4142 Assessment if relevant;
4. Planned Programme of Improvements / Noise Management Plan if relevant.

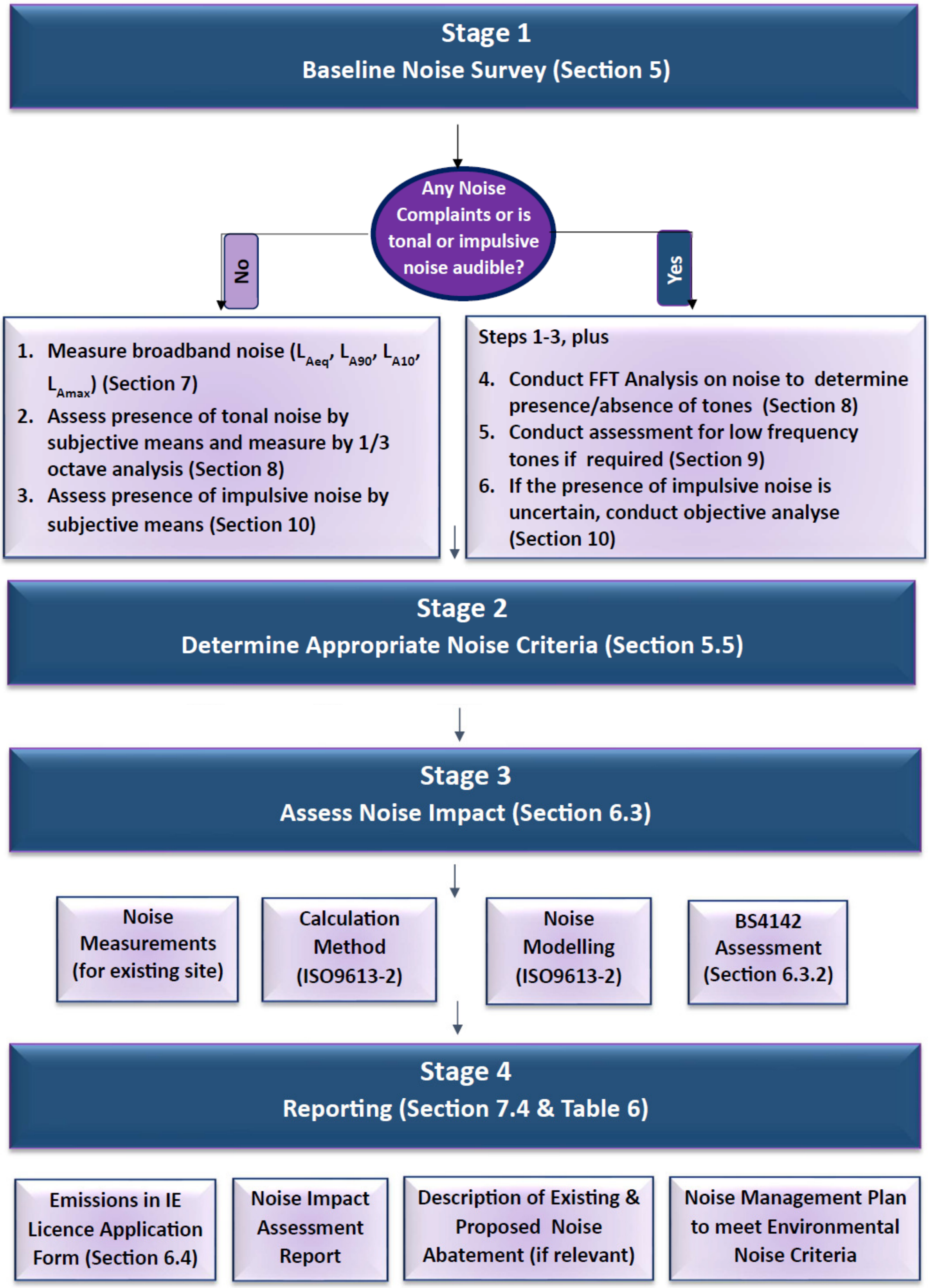
The noise survey, derivation of appropriate noise criteria, noise calculations (including full details of input data, methodologies and any pertinent assumptions) should be collated in a detailed technical report that is to accompany a licence application. This document should also clearly outline the process undertaken to identify appropriate noise criteria for the site as detailed in Section 5 of this document.

Baseline noise survey reports should provide the maximum sound pressure levels which will be experienced at typical points on the boundary of the operation or at typical noise sensitive locations, outside the boundary of the operation. The background noise levels experienced at the site in the absence of noise from this operation should also form part of the baseline assessment.

If a planned programme of improvement towards meeting noise criteria is required, this should have due regard to the noise management planning in Section 11 and also the noise control and mitigation measures outlined in Section 13 of this guidance note. This programme should highlight specific goals and a time scale, together with options for modification, upgrading or replacement, as required, to bring the emissions within the limits as set out in the guidance note.

Figure 12 provides a summary of the requirements for conducting a noise assessment for a new or revised licence application. In the case of a new facility, the baseline survey will measure the existing background noise in the area, before the activity commences.

Figure 12. Noise Survey for Licence Application or Review Application



7.0 ENVIRONMENTAL NOISE COMPLIANCE

An annual noise compliance assessment is normally required at licensed facilities. The nature and scope of the assessment should be determined by the site-specific conditions and operational history. At a minimum the survey should comprise daytime, evening and night-time surveys of sufficient length to satisfy the minimum survey duration for various periods (as outlined in Table 5) at each monitoring location identified in the relevant licence.

With regard to licences pre-dating the NG4 guidance (2012 and 2016), it is necessary to conduct daytime and night-time surveys of sufficient duration to comply with the requirements set out in Table 5 in Section 7.2.

The Agency would expect a licensee to undertake a more extensive noise assessment in situations where there has been a history of noise complaints, which is discussed further in Section 12.

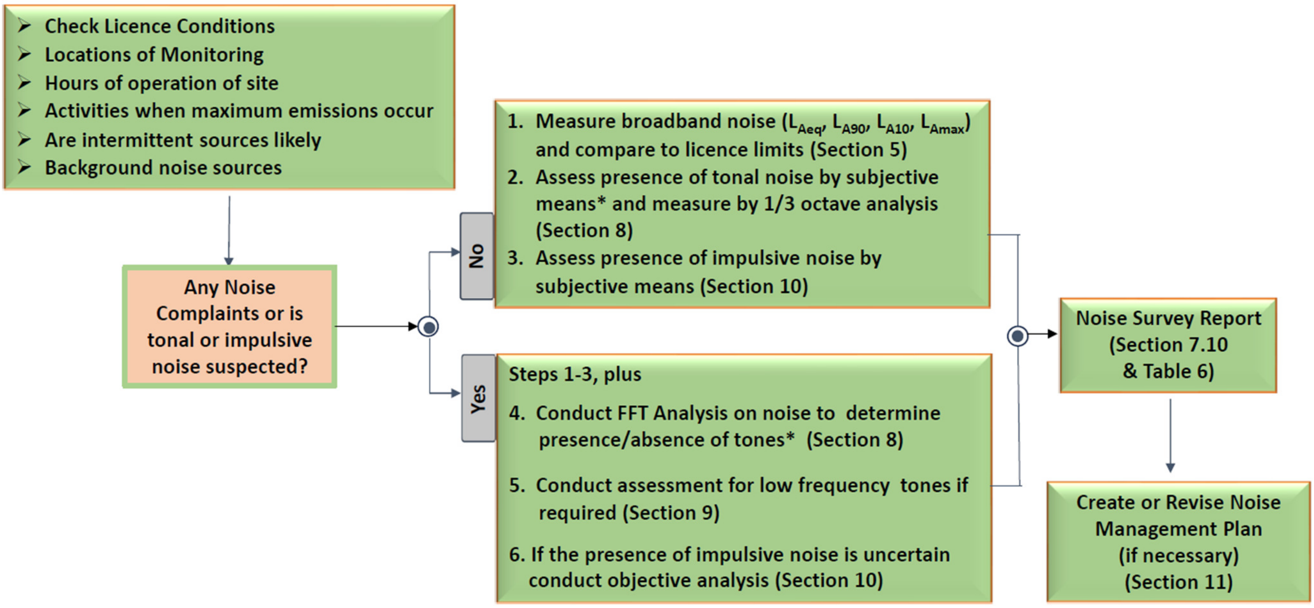
It is important to note that this guidance cannot be considered in isolation, and it must be interpreted in relation to the site-specific conditions pertaining to each site. Reference must also be made to relevant acoustical standards (principally ISO and British Standards). While the following sections in no way attempt to interpret the relevant provisions of these standards for every particular case, they do provide an overview of the methodology and assessment approach that is required for planning, site monitoring, analysis of data and reporting for the majority of Annual Noise Surveys.

7.1 Scope of the Noise Survey for Licence Compliance

A noise survey entails an assessment of broadband noise levels for comparison with the licence limit values and also an assessment of acoustic characteristics including tonal and impulsive noise. In planning a Noise Survey for licence compliance purposes, a number of factors need to be considered relating to the site, the nearest noise sensitive locations, the licence conditions and the background noise at the survey location. The requirements of a noise survey also depend on whether a complaint relating to noise has been issued to the site.

In situations where there has been a history of noise complaints, the Agency will normally expect a licensee to undertake a more extensive Noise Survey, using the methods outlined in this guidance and employ the services of a competent person in this regard. Figure 13 outlines the scoping process for a noise survey for licence compliance purposes and it distinguishes the difference in a survey where no complaints are issued, and tonal or impulsive noise is not present and a more extensive survey when these are present.

Figure 13. Noise Survey for Licence Compliance



**You can also use Appendix 4 to aid the subjective determination of tones (helpful aid - not part of standard procedure)*

Prior to conducting a survey, the acoustic specialist should examine:

- The requirements of the Licence conditions in relation to noise i.e. whether noise limits have been stipulated for boundary and/or NSL positions or for specific items of equipment/plant;
- The location, proximity and sensitivity of NSLs and other receptors;
- The characteristics of the noise sources at the facility, e.g. is the noise typically broadband, tonal, low frequency and/or impulsive;
- The nature and character of the locality and the background noise (i.e. ambient noise in the absence of noise from the specific facility);
- The occurrence of regular scheduled (although possibly infrequent) activities that may have a significant bearing on noise emission levels;
- The normal operating times of noise sources at the facility and any possible variations or irregular emissions. Intermittent emissions, even those of short duration, can cause annoyance and/or disturbance;
- Relevant changes at the facility (e.g. plant or operational changes) since the last noise survey;
- Any noise complaints issued to the site.

While the above list is by no means exhaustive, it does itemise some of the primary considerations. In practice the scope and the extent of the Annual Noise Survey will need to reflect the site-specific conditions and the operating history of the site.

In instances where a facility does not normally operate during night-time, certain noise sources may continue to function continuously (e.g. refrigeration plant and/or compressors). In most situations the survey work will need to be undertaken during daytime, evening and night-time. Only in situations where no noise sources whatsoever operate during night-time, will a daytime and evening survey suffice. Likewise, in situations where no noise sources whatsoever operate during evening and night-time, it will be sufficient to conduct a daytime survey only. In any event the timing of the survey work is a critical factor. It is important that the survey is undertaken during a period which is representative of typical or preferably worst-case operational conditions, i.e. when the site is operating at nominal maximum capacity.

It is recognised that practical constraints may preclude the survey from being undertaken during 'worst-case' conditions. However, all potentially significant noise sources at the facility should be operational at the time of the survey. If this is not possible, the survey report should draw attention to this fact and it should provide some justification for undertaking the survey work in the absence of a particular significant source. Where practicable, a predictive technique should be used to estimate the potential impact when the particular source is operational.

When an intermittent source does not cause any significant impact at any NSL or boundary position, it is permissible to proceed with the survey work during a period when such a source was not operational. However, the fact that the survey was undertaken under such conditions should be noted in the survey report.

Note that the Agency reserves the right to specify alternative and/or extended survey periods, when there is a history of non-compliances and complaints, in order to ensure that measured levels are wholly representative of site noise emissions.

Once the scope of the noise survey is determined, the practical considerations prior to and when conducting the survey, along with analysis and reporting of results is provided in the following sections.

7.2 Survey Methodologies and Assessment Procedures

Monitoring for compliance conditions of an Agency licensed site should be primarily based upon International Standard ISO 1996: Acoustics – *Description, Measurement and Assessment of Environmental Noise*.

It is important that the competent person understands both the local noise environment and the operating conditions of the site that are related to the generation of noise. This understanding should form the basis for determining both the times and length of the noise monitoring that should be designed to capture, as far as is practical, the worst-case scenarios with respect to the impact of the site noise at the NSLs. The noise report should include a justification for the selected measurement periods. Noise surveys for compliance with the licence (annual survey) are typically attended during the day, evening and night. Long-term (unattended) noise surveys may be more appropriate in certain circumstances such as baseline surveys for a licence application or in some cases, for a complaint investigation.

7.2.1 Annual Noise Survey

For an annual noise survey for licence compliance, ideally sampling over different days and at different times during the day will help to ensure that the survey is statistically representative. However, this may not be practical in all circumstances. Where noise emissions are relatively steady, a series of measurements should be undertaken as set out in Table 5.

Table 5. Recommended Minimum Survey Durations

PERIOD	MONITORING REQUIREMENTS
Daytime (07:00 to 19:00hrs)	A minimum of 3 sampling periods at each noise monitoring location i.e. 3 x 30 mins* consecutive readings at each NSL, plus assessment of tonal and impulsive noise.
Evening (19:00 to 23:00hrs)	A minimum of 1 sampling period at each noise monitoring location i.e. 1 x 30 mins* readings at each NSL, plus assessment of tonal and impulsive noise.
Night-time (23:00 to 07:00hrs)	A minimum of 2 sampling periods at each noise monitoring location i.e. 2 x 30 mins or 2 x 15mins readings at each NSL, depending on licence requirements, plus assessment of tonal and impulsive noise. *Night–time measurements should normally be made between 23:00hrs and 04:00hrs, Sunday to Thursday, with 23:00hrs being the preferred start time*

*Note: The sampling period duration may be reduced to 15 minute intervals in some cases with the agreement of the OEE inspector e.g. where traffic is dominant during day time hours. Agreement must be sought before deviating from licence conditions.

The minimum sampling requirements specified in Table 5 are mandatory for all annual noise surveys for licensed sites and will ensure that the noise results generated in respect of the licensed site are representative and reproducible. For sites where the licence does not specify an evening time survey (older licence), this does not have to be conducted but the daytime and night-time survey durations in Table 5 apply to these sites.

Most modern sound level meters can record audio during measurements, and this is a useful tool for assessment of noise reading after measurements are taken. 24-bit audio recording can also be analysed on dedicated noise software to assess the presence of tonal and impulsive noise.

It is important that the survey is undertaken during a period which is representative of typical or worst-case operational conditions, including the effects of weather. If this is not sensible or practicable on account of weather conditions, process cycles, extraneous noise interference or any other reason, then this should be stated in the report associated with the survey work.

Measurement positions are to be those stipulated in the Licence. In instances where a new noise sensitive receptor is built in closer proximity to the facility in question, that was not present at the time of the licencing process, the annual noise survey should be amended and additional monitoring should be carried out at any such location on an ongoing basis. Likewise, survey locations should be amended in the event that a former noise sensitive receptor no longer constitutes a NSL, e.g. a house that is demolished or subject to a change of use.

The selection of measurement positions is further addressed in Section 7.3. In practice, suitable positions will generally include points along the site boundary or positions at specified NSLs as per the relevant licence. Intervening ground conditions, buildings, distance and other factors affect noise propagation from a facility. Significant variations from the prevailing conditions applicable during preceding surveys should be noted.

It should be remembered that one of the objectives of the survey is to compare the measured noise levels at the current time with those at a previous time. All other factors should be as close as possible to being the same, at least over the representative sampling interval or period.

Measurements should be attended in most cases in order that the numerical values obtained can be confirmed by the assessment personnel as being wholly attributable to the activity under investigation. Attended measurements will facilitate the identification of extraneous sources and tonal elements.

All noise monitoring results and any derived averages should be rounded to the nearest whole integer, with 0.5 being rounded up.

If it can be demonstrated, on the basis of historical noise data and complaint history (or lack thereof), that a site is complying with its noise limit values and it does not give rise to unacceptable noise levels or annoyance, the Agency may agree to relax the survey requirements. Any such relaxation must be sought prior to survey work commencing and can only be given with the written agreement of the Agency. Conversely, the Agency may require a licensee to increase the frequency of monitoring in cases where there is a history of noise complaints and/or non-compliances.

7.2.2 Long-Term Noise Survey

In certain cases for licence compliance purposes, it may be appropriate to use long-term unattended noise surveys with audio recording, for example as part of compliance investigations or where the noise source is intermittent.

Note that long-term broadband noise readings are not suitable for assessment of low frequency noise complaints. Audio or frequency analysis samples should be used to evaluate low frequency noise issues.

For long-term unattended noise measurements, concurrent measurement of the weather conditions at the measurement location will be required, to eliminate data collected during high winds or rainfall.

Long-term unattended noise monitoring should be accompanied by attended readings to verify the source of noise recorded during the long-term survey.

7.3 Measurement Positions

Licence conditions should be consulted regarding measurement positions for noise survey purposes, if specified. If measurement positions are not specified, then an appropriate number of noise sensitive locations should be chosen for carrying out the noise survey. Given that the primary objective of the Annual Noise Survey is to determine the level of compliance, the measurement positions should include those positions which are most affected by the site emissions.

Generally, limits will be specified for NSLs. In some instances, noise measurements will be required at boundary positions or for specified pieces of equipment or plant. In the latter case, generally, a specified measurement position is given in a schedule to the issued Licence.

The noise limits which are imposed by licence conditions are 'free-field' levels, i.e. levels where the influence of reflections has been minimised. Whenever possible therefore, the noise measurement should be carried out at least 3.5 metres from any reflecting structure other than the ground. The preferred position for the microphone is 1.2 to 1.5 metres above ground level.

If there is local screening that could lead to a reduction in levels at 1.2 to 1.5 metres above the ground and there are sensitive receptors in the vicinity with accommodation at first floor level and above, the microphone height should be increased to *ca.* 4m. This is particularly important if there are night-time operations that could affect bedrooms.

In situations where measurements are being taken at an NSL, generally the boundary of the NSL (e.g. just outside the garden of a domestic house) can be the most useful measurement position. This helps to avoid the influence of domestic noise and also eliminates the need for trespass onto private property etc.

In certain instances, however, measurements at the boundary of a NSL may be supplemented by measurements close to the building of interest (i.e. facade levels). In the case of the latter, the appropriate measurement position would be 1 to 2 metres from the facade and 1.2 to 1.5 metres above each floor level of interest. If this approach is taken the appropriate façade correction should be made (as per ISO1996) when reporting the results obtained for direct comparison against the relevant noise criterion. Where it is proposed to undertake noise measurements late at night, then the notification of the local landowner(s) and neighbour(s) should be considered.

Where necessary, precautions should be taken in order to minimise the influence of electrical and electromagnetic interference, which can be caused in the sound measuring system by, for example, nearby power cables or radio transmitters.

7.4 Measurement Equipment

It is essential to ensure that the equipment used for monitoring can be guaranteed to perform within set tolerances.

7.4.1 Sound Level Meters

Various companies offer a number of different kinds of noise measurement equipment with several levels of complexity. The options include instrumentation that only measures basic time varying sound pressure level, at the lower end of the range, to those which have the functionality to perform statistical analysis, frequency analysis and record audio during measurement.

According to ISO 1996-2, sound level meters, microphones and calibrators have to comply with the requirements of a Class 1 instrument according to IEC 61672-1 for free-field applications. Filters shall meet the requirements for a Class 1 instrument according to IEC 61260. Therefore in Ireland, a Class 1 instrument shall be used for noise measurement by all parties involved in the assessment of noise. If calibrated recordings are obtained for the purposes of off-site analysis, it is the responsibility of the competent person conducting the assessment to demonstrate that the entire measurement and analysis chain complies with the Class 1 requirements.

Sound level meters used for the purposes of licensing, measurement and assessment should be capable of measuring and storing the A-weighted equivalent sound level ($L_{Aeq,T}$), statistical indicators (e.g. $L_{AF90,T}$, $L_{AF10,T}$), maxima/minima (i.e. $L_{AFmin,T}$, $L_{AFmax,T}$) and tonal noise components including 1/3-octave band data and 24-bit audio recordings to allow for subsequent FFT narrowband frequency analysis via dedicated software. The principal noise index to be recorded will generally be the $L_{Aeq,T}$, the continuous A-weighted sound level containing the same amount of acoustical energy as the measured varying noise over the measurement period, T. This time period must be specified for the measurement result to be meaningful.

Most modern instrumentation will provide two different exponential time weightings – 'fast' (with a nominal exponential time constant of 125 milliseconds) and 'slow' (nominal exponential time constant of 1 second). Fast is generally the preferred time-weighting, especially for statistical data and for variable noise levels.

Modern sound level meters usually have a wide dynamic range of around 80dB or more and can measure peak levels of over 140dB. The measurement scales go down as low as 20dB and below. However, meters and microphones constituting measurement chains will produce electrical noise which can influence readings. It is recommended that any noise level measured below 25dB should be viewed with caution and manufacturers should be consulted in relation to the noise floors associated with their instrumentation. Care should be taken in selecting the most appropriate dynamic range setting in order to exclude overloaded and under-ranged measurements. Overloads in particular could give rise to significant errors in measurement results.

Microphones should always be mounted and oriented in accordance with the manufacturer's instructions, with due regard to directivity characteristics.

If long–term measurements are being carried out, care should be taken to protect the instrument and microphone, ideally using the manufacturer's recommended approach in order to maintain measurement integrity.

7.4.2 Calibration of Sound Level Meters

Field Calibration

Each sound level meter system should consist of the meter itself, along with a calibrator and dedicated microphone. According to ISO 1996-2, the calibrator shall meet requirements for a Class 1 instrument according to IEC 60942. A typical field calibrator produces a tone of 94dB SPL at 1kHz.

As a matter of good practice and in line with relevant standards, sound level meters should be calibrated in the field with appropriate acoustic calibrators before each series of measurements and checked on completion, to ensure accuracy of the readings. According to ISO1996-2, if the difference between the readings of two consecutive checks is ≤0.5dB then the noise measurements are satisfactory.

For long–term measurements where the meter is not moved or exposed to extreme conditions, then the measurement chain should be calibrated (using an acoustic calibrator) at intervals of between 3 months and 1 year. However, more frequent calibration intervals may be undertaken as required by the surveyor at their discretion.

Calibration levels are to be recorded (often the instrumentation itself logs calibration events). Some long-term noise monitoring systems are capable of performing automated, periodic calibration routines. The validity of such routines should be clarified with the manufacturer and subject to this being satisfactory, may be used to supplement regular acoustic calibrations.

The surveyor should note if the drift between calibration sessions and if it is ≥0.5dB, the noise readings since the previous satisfactory check shall be discarded, for both long- and short-term measurements.

Laboratory Calibration

An accredited laboratory must calibrate sound level meters and calibrators on a periodic basis. ISO1996-2 specifies that all compliance testing shall be conducted by a laboratory meeting the requirements of ISO 17025 and that compliance shall be verified with a valid certificate of compliance meeting the requirements of relevant test methods.

The Agency recommended time-interval for laboratory calibration is;

- ✓ **Sound level meters** should be verified to traceable standard at least every **two years.**
- ✓ **Acoustic calibrators** must be calibrated at least **once a year**.

7.5 Noise Indices

The fundamental requirements for the Annual Noise Survey are to determine whether or not the licensed activity complies with the noise limit values as set out in its licence and to ensure that there is no evidence of tonal or impulsive characteristics, particularly at night-time. While a subjective assessment of the presence of tones and impulsive elements can be made, appropriate procedures for objective assessment of tonal noise, low frequency noise and impulsive and intermittent noise are presented in the following sections.

In many instances the A-Weighted sound pressure level serves as an adequate descriptor and while $L_{Aeq,T}$ and $L_{Ar,T}$ are the most commonly used indices, percentile levels should always be reported. This will help to further describe the characteristics of the measured noise.

While modern instrumentation will permit the logging and recording of a substantial number of indices, the following standardised parameters are considered to be important: $L_{AF10,T}$ and $L_{AF90, T.ra2c}$.

As a minimum, the following meteorological data should be recorded and reported during long and short term noise surveys. The presence/absence of precipitation is sufficient to note during a short term survey:

- Wind speed
- Wind Direction
- Temperature
- Precipitation

Other notable weather conditions that should be reported include cloud cover, fog, wet ground, frozen ground or snow cover.

Measurements should generally be avoided in rainy or dense foggy conditions. Common sense must be used at all times to protect the instrumentation and the prevailing conditions must be clearly stated to allow a qualitative judgement to be made on the validity of the measurements.

Temperature and humidity can affect the air absorption of sound waves, although in practice these effects are often much less than those of distance, barriers, wind and the like and are unlikely to have a significant effect, especially at low frequencies. However, under some conditions, such as temperature inversions, which can arise during calm nights with little cloud cover, sound propagation can become very complex and result in localised focussing of noise. If this is considered to be an issue at hand, specific advice should be sought from a competent person.

For long-term measurement surveys, a rain gauge and anemometer will be required in conjunction with the sound level meter for the duration of the survey. Maximum permissible error for weather measurement instruments for a long-term monitoring survey are stated in section 5.4 of ISO 1996-2:2017.

In general, noise attributable to wind and or rain should be at least 10dB below the noise source being measured, otherwise the measurements may be unduly influenced.

7.6 Ground Attenuation

If the intervening ground between a noise source and a measurement location is acoustically absorptive, this can result in a reduction in noise level at the receptor due to absorption of sound energy by the ground itself. This aspect particularly needs to be considered when propagation distances are above 300m.

Acoustically absorptive ground types include grassed areas, tillage fields and forests with ground covering vegetation. Examples of acoustically reflective ground would be areas of water and concrete.

The proportion of hard and soft ground between the source and the receptor point should be noted as a simple percentage (e.g. 50% grassland, 50% water). If the ground attenuation conditions are considered to vary appreciably with the seasons, the noise survey should ideally be carried out at a time when ground absorption is at a minimum, so this corresponds to a time when public reaction to the facility is likely to be highest.

Ground attenuation has little effect on high level sources when the receiver has a clear line of sight to the source. Ground effect may be greatly reduced or even eliminated where an acoustic barrier is in place, but this may not apply where low frequency noise is an issue.

7.7 Noise Attributable to a Particular Activity

The limits and conditions of any EPA Licence apply to one specific site, i.e. the licensed activity. However, it is possible that over time other industries or sources of noise will encroach on an area that was previously only affected by the licensed site. This produces some significant difficulties in measuring the noise that is attributable to the licensed site alone. However, there are several techniques that can be applied to assist in identifying noise attributable to a particular source. These techniques generally require a high level of competence in acoustic measurement.

These would include, for example, the use of L_{A90} values instead of L_{Aeq} for steady noise sources (Section 7.5) and the use of narrow band frequency analyses (Section 8) to identify the tonal contributions from particular items of plant to confirm that they are from the licenced site.

For facilities that operate continuously for 24 hours, it may be appropriate to measure at a time when all (or most) other noises have subsided. This will often mean measuring late at night when general traffic noise has reduced. Where noise output from the facility can be temporarily eliminated or subdued, it may be possible to estimate the facility’s specific noise level by measuring the noise level with and without the facility running. The use of pausing techniques and short-term sampling intervals may also help to ascertain the noise attributable to the source of interest.

If the specified measurement position is a significant distance from the noise source with few intervening barriers or buildings, it may be possible to measure closer to the source where there may be less extraneous noise and then calculate the ‘attributable’ noise contribution at the greater distance using standard techniques. However, it is not valid to take measurements very close to a particular source and then calculate these levels. The closest reliable position at which measurements may be taken is at a distance of at least three times the largest dimension of the noise source. For example: a distance of at least 15m from a cooling tower with noise radiating more or less evenly from all elements with dimensions of 5m x 3m x 4m.

If it is not possible to measure at the optimum position, e.g. for safety reasons, this should be clearly stated and due account taken of the likely effect on the measured values.

Appropriate guidance in relation to the accurate determination of specific levels is provided in BS 4142:2014+A1:2019 section 7.3 *Determination of the specific sound level*. This should be applied in the event that there is any difficulty in obtaining results that are wholly attributable to the activity under investigation. Details on BS4142 assessments are also outlined in Section 6.3.2 of this guidance document.

7.8 Interpretation of the Results

The interpretation of the measurement results will form a critical part of the report and it should include a general description of the measurements, including a summary of the levels of the various noise descriptors for the relevant time periods. Special note should be made of the character of the sound and the presence or otherwise of tones or impulsive elements. The report should highlight whether the rating level was adjusted to account for these tonal or impulsive elements. Subjective comments on audibility and the dominance of noise sources should also be included, along with difficulties in identifying sources etc.

The report should clearly interpret the noise results and highlight whether noise from the activity or extraneous noise sources are the dominant contributors to the noise levels measured. This interpretation should be based on the various noise measurements and any comments included on the dominant and/or intermittent sources of noise at the various measurement locations.

It is acknowledged that, on some sites, extraneous noise sources unconnected with the activity under consideration may unduly influence the measurements. In such situations, every effort should be made to ascertain the site-specific noise level by following the approach set out in Section 7.8. Where findings remain inconclusive in this regard, it may be appropriate to use the $L_{AF90,T}$ indicator to give a good indication of the actual noise output from the site, provided noise emissions from the site are steady. For example, if a measurement location is situated near to a busy road, the $L_{AF90,T}$ indicator might provide a more accurate representation of the magnitude of site noise emissions through the exclusion of contributions attributable to vehicles passing by. Note that, even if $L_{AF90,T}$ is used to assist with the interpretation of noise emission data attributable to a given site or activity, the measured values for $L_{Aeq,T}$ must also be presented in the report. The reasons for the use of $L_{AF90,T}$ must also be presented in order to ensure that its use is justified.

The report should also outline any steps taken to reduce uncertainty in accordance with the guidance given ISO1996-2 and/or BS 4142: 2014+A1:2019. A statement of uncertainty or a table of the factors that affect the results with an estimate of the effect of each (low, medium or high) should be provided as a minimum. Steps take to reduce uncertainty should be outlined e.g. calibrating the instrumentation before and after measurement (drift ≤0.5dB), avoiding periods of inclement weather, position of measurements (free field, reflective surfaces), source of met data (10m or site surveyor level), period of measurement, frequency of measurements, or other indicators of uncertainty that may have arisen during the survey.

7.9 Noise Survey Report

The results of the Annual Noise Survey Report must be submitted to the EPA (via return on EDEN). Table 6 contains a template for an annual Noise Survey Report that may be used for compliance purposes, which should be reviewed for all reports, prior to the submission to EPA. If the EPA deem that the report is incomplete or does not contain enough information to allow a valid assessment of noise impact to be made in line with these guidelines, then the report can be rejected and further assessment will have to be conducted.

In situations where complaints are made, a more detailed assessment of tonal noise, low frequency noise, impulsive noise, intermittent noise or other sound characteristics following the methods provided in this guideline will have to be made and include in the report for assessment purposes.

The Noise Survey Report should include tabulated values of the measured and rated noise levels for each measurement period. Comments should also be made regarding the variation of these descriptors throughout the measurement period. A sample tabulated format for results is provided in Appendix 3, which could be adopted for this purpose noting that compliance is based on individual measurements and not the arithmetic average.

Where 1/3 octave band or narrow band frequency analysis has been undertaken, the frequency spectra are to be included with the report. 1/3 octave band data should be submitted in both tabular and graphical format and reviewed according to Section 8 of this document. Note that, in instances where extraneous noise sources (e.g. road traffic noise) dominate L_{eq} noise spectra, appropriate consideration may be given to the L_{AF90} spectrum that may be more representative of site noise emissions alone.

Finally, the measurement report should include a statement of compliance, or otherwise, with the licence conditions along with clear statement of the levels of noise associated with the facility in question at the various measurement locations. In certain instances, this will require detailed review of the noise levels and acoustic characteristics and a simple statement of the measured noise level will not suffice.

Table 6. Annual Noise Report Template

	Content	Information to Provide
	Executive Summary	✓ Short summary of monitoring conducted. ✓ State clearly whether noise licence conditions have been complied with.
1	**Introduction**	✓ Site name, address and licence number & dates of survey. ✓ Scope and objective of survey. ✓ State licence conditions and limit values relating to noise. ✓ List the site operations, hours of operation and noise sources. ✓ Describe the site processes / activities occurring during the survey. ✓ Details of any noise complaints in the last year. ✓ Statement of competency of personnel who conducted the noise survey, drafted and approved the report as per Section 4 of NG4.
2	**Methodology & Instrumentation**	✓ List of relevant standards and guidance used for monitoring and reporting. ✓ Description of noise measurement locations and intervening ground between site and NSL & include map. ✓ Photographs of sound level meter in each monitoring setting – Note that photographs should avoid where possible including clearly recognisable features or identifying location markers associated with private property. ✓ Noise instrumentation used, include details of the following as a minimum: o Manufacturer, model type and serial number of the sound level meter, calibrator and microphone used for annual survey (include certificates of calibration in appendix). o The type of windshield and other microphone attachments used. ✓ Details of field calibration checks including the offset change and the field calibration result. ✓ The frequency weighting networks and meter response time (i.e. fast or slow). ✓ Details of measures to exclude extraneous noise and reference to the methodologies followed throughout the survey. ✓ A description of the meteorological conditions during the survey. ✓ Instrument used to collect met data & weather conditions during survey.

	Content	Information to Provide
		✓ Software used to analyse data. ✓ Statement of uncertainty (refer to Section 7.9).
3	**Results**	**3.1 Noise Measurement Results** ✓ Provide summary table of noise measurement results (L_{Aeq}, L_{A10}, L_{A90} & L_{Amax}) with time & duration of Day, Evening and Night readings and a description of noise sources on and off site for each reading. Provide relevant tables, graphs and other details in Appendix. ✓ State if tonal and / or impulsive noise was present during each measurement. ✓ State the justification for any use of LA90 for assessing compliance with licence conditions, backed up by noise data. **3.2 Tonal Noise** ✓ Provide 1/3 Octave noise data in tabular and graphical form for day/evening and night for each location. ✓ Provide details of all additional assessments conducted into potential issues of tonal or low frequency noise or where complaints have been received, e.g., low frequency analysis, FFT analysis and penalties assigned as per Section 8 and 9. **3.3 Impulsive Noise** ✓ Where impulsive noise is audible, provide details and assign impulsive penalty. ✓ Provide details of all additional assessments conducted into potential issues of impulsive noise or where complaints have been received, as per Section 10. **3.4 Noise Rating** ✓ Provide table with noise rating ($L_{Ar,T}$) for day and evening readings i.e., the measured LA_{eq} noise reading + penalty, and compare with licence limits. Note that there shall be no clearly audible tonal or impulsive noise at night time, as specified in the licence.
4	**Conclusion**	✓ State, with supporting justification, whether the noise assessment at each location complies with limit values and licence conditions. ✓ Where results show a non-compliance with the licence, state what further work will be done to investigate noise and create a Noise Management Plan.

8.0 TONAL NOISE

Noise that includes tones is more annoying than noise without such characteristics. Consequently, it is very important to evaluate any tonal content accurately when assessing environmental noise. Some noise sources and industrial activities are inherently likely to give rise to tonal noise, examples of which include fans, compressors, motors and transformers. Mains electricity can also be a common source of tonal noise. In this instance tonal content may be easily identified as it is at multiples of the frequency of the electricity supply, at exactly 50Hz and multiples.

In order to take into account the fact that tonal noise is more noticeable and intrusive than broadband noise, it is appropriate to penalise tonal noise in assessments by applying a correction factor to the measured noise level in order to arrive at a 'rating level'. The rating level ($L_{Ar,T}$) is calculated by adding a tonal penalty to the measured equivalent continuous A-weighted sound pressure level ($L_{Aeq,T}$). The purpose of the rating level is to arrive at a better estimate of the potential community response to the measured noise.

Note that low frequency tones are generally much more noticeable indoors as the sound transmission loss of windows progressively attenuates higher frequencies, leaving the low-frequencies more prominent. Low Frequency Noise is discussed further in Section 9.

Acoustic software can also be used to identify possible tones over a monitoring period by examination of Real Time Analyser (RTA) or spectrum analyser plots, which can indicate whether the same tones/bands are present over a monitoring period and whether these are repeated.

Frequency analysis is conducted at noise sensitive locations to determine the presence/absence of tones. The recommended period for frequency analysis will depend on the type of noise source and the choice of averaging period is a decision that should be taken by the competent person based on the circumstances.

- For non-varying, broadband non-tonal sources, simple averaging over the full period (e.g. 15-30 mins) would be acceptable. These are situations where tonal noise is not audible subjectively and not likely to be present and where there is no history of complaints.
- Where tonal noise is suspected and the dominant noise source is continuous and where the background noise does not vary dramatically, then a shorter period is a sufficient, once it is representative of the source under investigation.
- Where tonal noise is suspected and variable in frequency e.g. a variable speed fan, then averaging for long periods will "smear" the tonal element over a range of frequencies. This could lead to a serious underestimate of the tonal content. Under these circumstances, a short averaging period should be used, the length of which is determined by the rate of variation in frequency, with rapid variation requiring a shorter period.
- For varying broadband sources, select a period that provides the most accurate worst typical case evaluation of the frequency content of the source(s). Note that some instrumentation can provide percentile 1/3 frequency analysis and where this is available to the surveyor, this is an option for these circumstances.

Dominant and simple tonal noise sources can often be subjectively identified by a competent person familiar with noise impact assessments. There are also objective methods to determine tonality and two standard methods are discussed in the following sections; 1/3 octave analysis and narrow band frequency analysis (FFT).

Subjective determination of tones (listening) and 1/3 octave-based methods are commonly used in acoustic practice, but this is usually not sufficient in identifying tonal content (hum, whine, drone squeal etc), except where there are only one or two tones that are fairly obvious. The preferred method where there is any doubt is to use narrow band frequency analysis (FFT).

Tonal Noise Method 1	Tonal Noise Method 2
Subjective & 1/3 Octave Analysis using ISO1996-2 Annex K	Narrow Band Analysis using ISO1996-2 Annex J (FFT)

8.1 Tonal Noise Method 1: Subjective & One-third Octave

Many people struggle to identify tones subjectively i.e. by listening to the noise, unless they are very obvious. Consequently their identification is often missed using subjective means alone. Appendix 4 provides a useful aid to subjective determination of tones using a smartphone app. While subjective methods may be useful, these must be supported by objective evidence to verify their presence or absence. The first recommended objective method is 1/3 octave analysis which can be viewed live on most meters while listening, which is a simplified method, easy to undertake and can identify if prominent tones are present.

The simplified methodology for the objective identification of tones is advocated in ISO1996-2 Annex K (Survey Method). This methodology requires that for a prominent, discrete tone to be identified as present, the time-averaged linear dB(Z) sound pressure level in the one-third-octave band of interest is required to exceed the time-averaged linear dB(Z) sound pressure levels of both adjacent one-third octave bands by some constant level difference. The appropriate level differences vary with frequency. They should be greater than or equal to the following values in both adjacent one-third-octave bands:

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

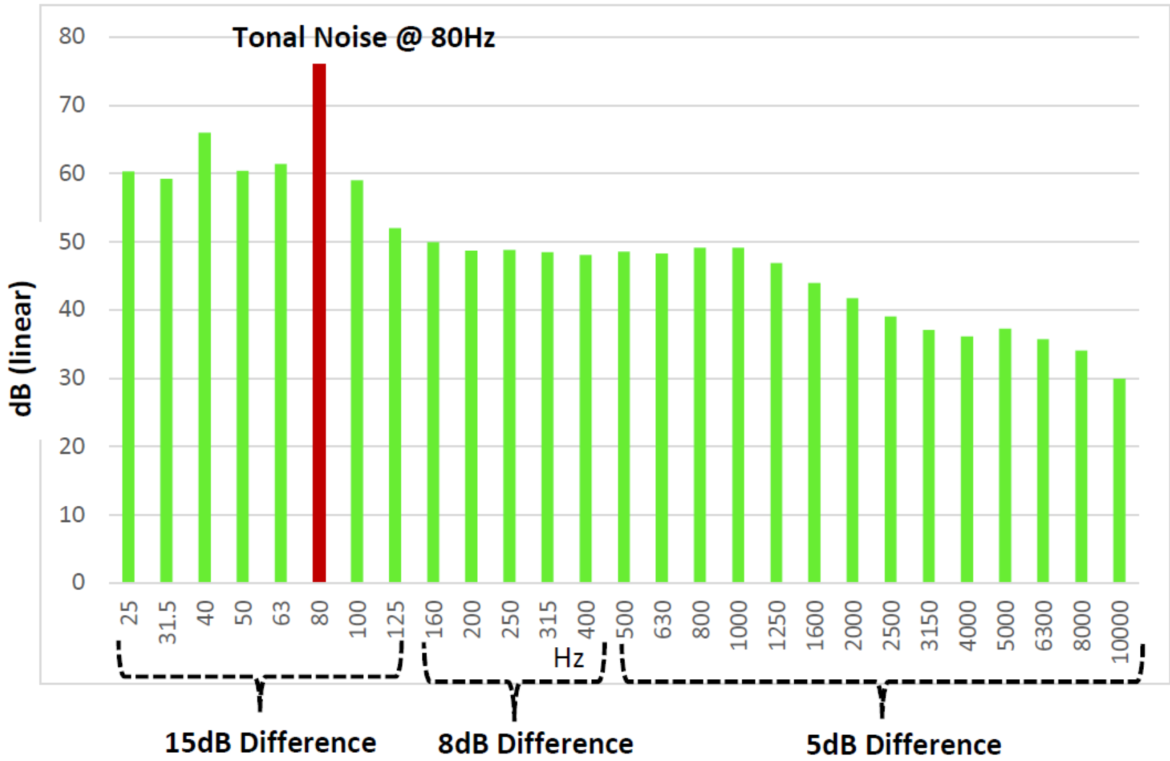
Care should be taken to ensure that any tones identified in the low frequency range of 25Hz to 125Hz are of a magnitude greater than the threshold of hearing at that frequency as shown in Table 7. Low Frequency Noise is discussed further in Section 9.

Table 7. Threshold of Hearing for 1/3 Octave Band Centre Frequencies

Hz	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160
dB L_{eq}	92	87	83	74	64	56	49	43	42	40	38	36	34

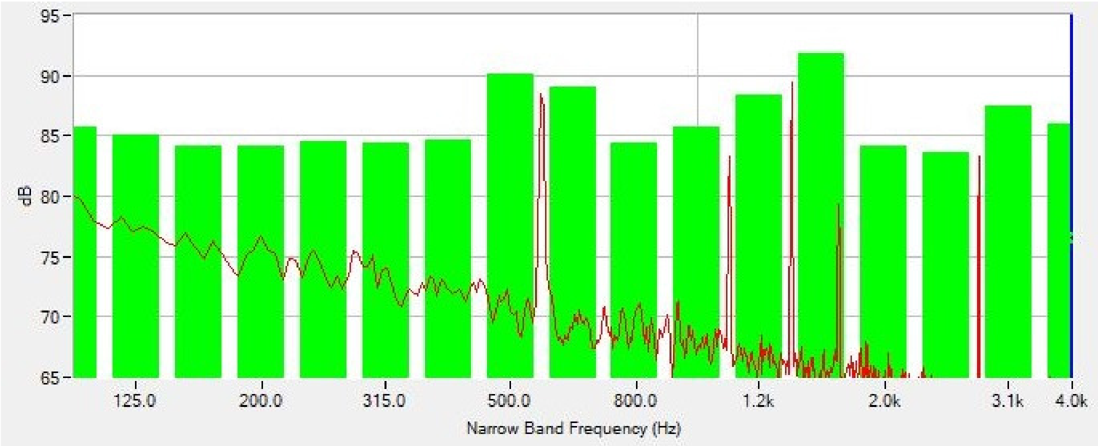
In order to illustrate this methodology, Figure 14 gives an example where a tone has been objectively identified at 80Hz. Its presence is confirmed due to the fact that the level difference between the tonal frequency and the level in each of the adjacent one-third octave bands is greater than or equal to 15dB.

Figure 14. Example of 1/3 Octave Tonal Noise



The 1/3 octave approach should be used with caution as it may not be sufficient to identify tonal content i.e. it may suggest that no tones are present in clearly tonal noise. For example, Figure 15 shows the noise frequency spectrum from the same noise source taken with 1/3 Octave analysis (green) and narrow band analysis (red). The 1/3 octave method does not identify any tone but the narrow band analysis identifies very high-level tones that are approximately 15dB and 30dB above the background. In this case the one-third octave method is not sufficient and it may be appropriate to apply the more detailed reference/ engineering method.

Figure 15. Overlay of Narrow Band and 1/3 Octave Band Analyses



8.2 Tonal Noise Method 2. Narrow band analysis

The second method for objective determination of tones is by narrowband frequency analysis, which represents good practice and should be carried out as a minimum in all cases where:

- The surveyor or an interested party believes that a tone is clearly audible even though the one-third method suggests that a tone is not present;
- Where multiple tones are present (as shown in Figure 15);
- In a complaint situation;
- If measurements conducted under different conditions and/or at different times return contradictory findings, i.e. application of the one-third method suggests the presence of a tone for one or more measurements whilst also suggesting the absence of a tone for another measurement (or measurements), and
- If the level differences are within ±2dB of 15dB (25-125Hz), 8dB (160-400Hz) & 5dB (500-10,000Hz) and there is a dispute over the presence or otherwise of a tone.

The recommended reference method in the instances above is to adopt the methodology outlined in ISO1996-2: Annex J (normative): *Objective method for assessing the audibility of tones in noise – Engineering Method*.

Application of the reference method is a complex procedure, which has three steps:

a) Narrow-band frequency analysis, preferably FFT analysis (linear averaging for at least 1 min);

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, ΔLta, and the adjustment, *Kt* .

Many commercially available acoustic software packages automate this method once 24-bit audio recordings are available from the calibrated sound level meter, which can be analysed after measurements are taken.

The choice of averaging time for FFT analysis depends on the site circumstances, how long a tonal noise source may be present, etc and this decision is to be taken by the competent person. FFT tonal analysis should always be carried out when the effect of extraneous sources is minimised (e.g. passing traffic or birdsong) and these periods can be identified by looking at the graphical data from the measurement period ($L_{Aeq_}$dt).

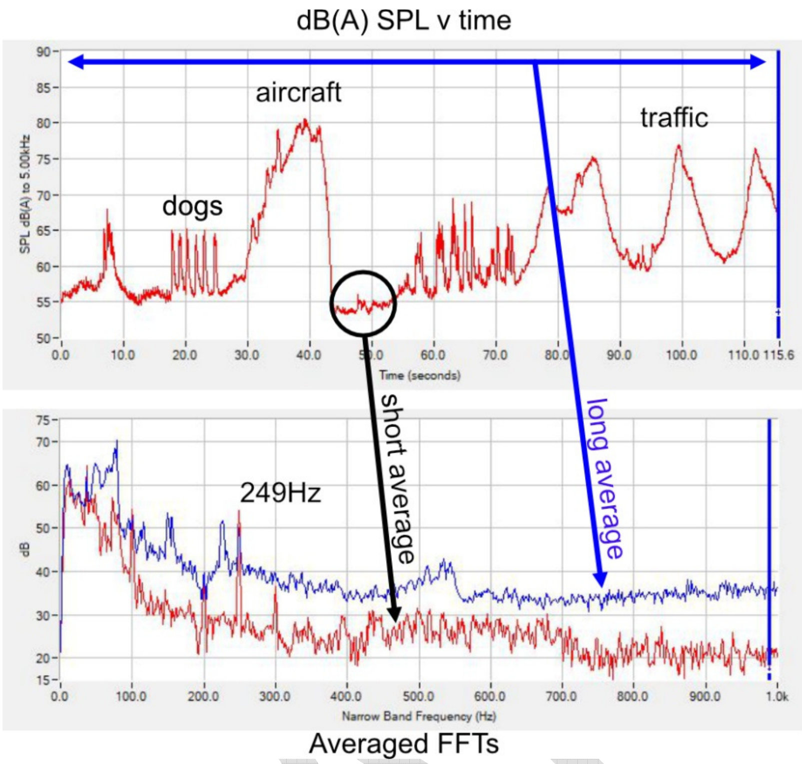
If FFT analysis is carried out on the complete noise monitoring event (15-30mins), the extraneous noise data may mask tones and no tones may be identified. Therefore, it is important to look at the graphical data and analyse for tones when extraneous noise is absent and see if there are consistent or intermittent tones present at the noise sensitive location that may be attributed to the site in question. Details of the averaging time used and the justification for their use should be included in the report.

In addition, for reporting purposes, tabulated results may be provided (software allows for exporting of results of prominent tones, audibility and penalty adjustment). A graphical plot of noise v time showing the period over which the FFT was taken should also be provided. If possible, provide the FFT analysis plot and report the frequency of tone and penalty assigned.

An example is provided in Figure 16 where a short period FFT analysis was undertaken by acoustic software on audio recorded during a short period when the extraneous noise at this location was at a minimum. A high amplitude tone at 249Hz that is 20dB above the background can easily be identified (red trace). Whilst this tone is present throughout the recording, the longer-term averaged FFT analysis (blue trace) does not represent the true impact of the tone as it appears to be only marginally above the background.

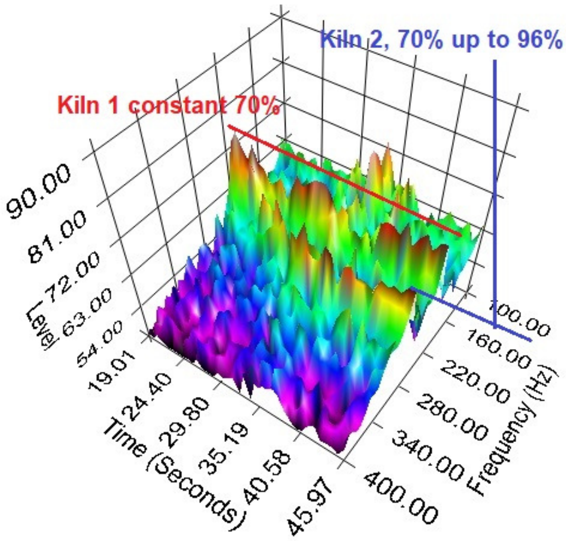
This method can also be used for long-term noise measurement data when intermittent tonal noise can be present, as intermittent tones can be seriously disturbing. In a complaint situation, correlation of information when the complaint can hear the tone and FFT analysis of the data for these time-periods will corroborate if a tone may be present.

Figure 16. Sample of FFT Analysis



An alternative if software permits, is to display the variation in frequency content over time as a 3D waterfall plot as shown in Figure 17. This example shows the variation in 2 kiln fan tones over time. One fan is running at constant speed (70% of full speed) while the 2nd fan ramps ups from 70% to 96% of full speed, increasing the frequency of the tone.

Figure 17. 3D Waterfall Plot Sound Spectrum



8.3 Tonal Noise Penalties

Where a tone is detected by 1/3 octave analysis or narrowband frequency analysis (FFT), then a penalty of up to 6dB is assigned. ISO1996-2 provides guidance on tonal noise penalties and is the preferred method for the determination of tonal penalties.

As discussed in section 8.2, some FFT analysis conducted by acoustic software automatically assigns a tonal penalty and this is to be added to the measured L_{Aeq} for noise rating purposes, for comparison to licence limits. Therefore, for licensed sites, objective FFT analysis is the preferred method when assigning a tonal penalty.

Where is tone is detected subjectively or with assistance from the smartphone app detailed in Appendix 4 and by 1/3 octave analysis, then it would be appropriate to assign a 6dB penalty, as 1/3 Octave analysis identifies prominent tones. Where a tone is not detected by 1/3 Octave analysis but is suspected or identified by narrowband frequency analysis using a smartphone app, then FFT analysis should be used to determine if a tone is present and to determine what penalty rating is appropriate.

Licence conditions typically specify that there shall be *no clearly audible tonal component* at a noise sensitive location at night time. Therefore, a tone which is assigned a FFT penalty of 3dB may not be clearly audible to the majority of the population and could be acceptable at a noise sensitive location, provided no complaints are issued to the site. This is to be determined on a case-by-case basis at each noise sensitive location where this occurs.

Where complaints are issued and a low tonal penalty is objectively determined by FFT, then the potential reasons are:

1. Most complaints are made about noise indoors whereas the penalty is applied to the tone measured outside. Once the sound has passed through windows, the signature changes as the transmission loss is frequency dependent. Consequently, the penalty assessed indoors could be significantly different to that assessed outside.
2. There may be standing waves indoors that amplify particular frequencies at certain locations. This can have a dramatic effect on the assumed penalty based on external measurements.
3. The complainant may be sensitive to the tone.

Consequently, further investigation is warranted to diagnose if the licensed site may be causing the tonal noise and implement noise control measures where appropriate (Section 13).

A tonal penalty of ≥4dB at night time is a clearly perceptible tone and if present at a noise sensitive location, then corroboration of the same tone from the site is necessary. If the source is found on-site, then this is a non-compliance with the licence, even when the night time L_{Aeq} noise level is under the limit value.

In all cases where FFT detects a tone and assigns a tonal penalty, the context of the tone needs to be taken into account i.e. is it present when extraneous noise sources are absent, or are there other nearby sites or plant and equipment that may contribute to tonal noise. If a tone is identified, the next stage is to diagnose if the same tone is present on the licensed site by measurement of noise sources on-site (Section 11.5) and implement noise control measures where appropriate (Section 13).

Any non-compliance in the licence regarding noise, noise complaints/incident shall be reported to the Agency, as specified in the licence conditions.

If more than one adjustment is potentially applicable for the type or character of a given single sound source at a noise sensitive location (i.e. a source that is both tonal and impulsive), then both adjustments shall be applied.

All licensed facilities should use BAT to attempt to eliminate and control tonal components when identified, although it is acknowledged that it may be impractical to always completely eliminate some of these characteristics. At night-time, however, there should be no clearly audible tonal noise at any Noise Sensitive Location.

9.0 LOW FREQUENCY NOISE

Low Frequency Noise (LFN) can be an environmental noise problem and can result in noise complaints to licensed sites. Not everyone can hear it and in many cases where it is present, it is difficult to identify the source. For those who are affected, it can be most noticeable at night. Low Frequency Noise is not clearly defined, but it is generally taken to mean noise below a frequency of about 200-300Hz and is usually associated with noise at the lower end of this scale. LFN is frequently perceived as a throb, a low rumbling or a 'hum'. Note that the dB(A) parameter is of no use when evaluating LFN and its presence needs to be determined by measuring linear (dB(Z)) narrow band or 1/3 octave frequency analysis over the frequency range from 10 to 300 Hz. Many of the assessments and control techniques which pertain to everyday noise sources do not apply to low frequency noise.

ISO 1996-2 refers to low frequency sound measurement in terms of specific locations for measurement in indoor and outdoor settings and this may be referred to when low frequency noise is suspected. BS4142 refers to NANR45 for the assessment of low frequency noise.

Proposed criteria for the assessment of low frequency noise disturbance (NANR45) were produced by Salford University (2005, Revised 2011). The Appendix at the back of NANR45 provides useful guidance on the type of information to collect when conducting a LFN assessment. A summary of the main guidance from NANR45 is provided in this section, along with a field method/procedure to aid assessment of LFN.

The human ear, for the majority of people, is not very sensitive at low frequencies. At low levels of noise, the human ear attenuates sound (reduces it) by about 25dB at 100Hz, 40dB at 50Hz, and 70dB at 20Hz. While hearing deteriorates more rapidly at the mid and higher frequency, generally older peoples' hearing tends to be proportionately more acute at low frequencies. In addition, tinnitus (which become more common with age) can also be an issue. Some of the problems pertaining to low frequency noise are associated with the fact that mid and high frequency noise is attenuated by propagation through atmosphere and by ground effects. In some instances, this results in an emphasising of the low frequency noise content.

In addition, the transmission loss through windows progressively attenuates higher frequencies, emphasising LFN content. Moreover, standing wave resonances can be set up inside rooms with nodes (quiet points) and anti-nodes (loud points) dependent on the room dimensions and the frequency of the noise. These room resonances can cause elevated levels of low frequency noise at certain locations within a room.

Possible sources of LFN include industrial and/or commercial plant and equipment (e.g. pumps, fans, cooling towers, vibratory hoppers and screens etc), electrical installations, wind farms, road, rail, sea or air traffic and amplified music. LFN can also be domestic in origin (e.g. refrigerators, oil fired burners). LFN can be easily transmitted through structures and airborne noise can cause windows and other elements to rattle. Thus the source's direction may be unclear and there may also be difficulty in deciding whether the noise is airborne or structure borne (vibration).

9.1 LFN Measurement

There are some key questions that need to be answered during the initial investigation of a potential LFN problem. The answers to these questions determine the best measurement strategy.

1. Tonal LFN?

If it is suspected that tonal low frequency noise is the source of complaint, then there are potential issues with standing waves within one or more rooms, depending on the room dimensions. This complicates matters as the LFN tonal noise level can vary by 10dB or more over a distance of as little as 1m within a room.

For this reason, it is important to first conduct narrow band frequency analysis to determine if a tone is present (using a smartphone app as detailed in Appendix 4 or other software). Alternatively, if the tone is clearly evident by 1/3 octave analysis, then this can be used instead.

If tonal noise has been confirmed, then the baseline measurement should be an area average over the entire area of the worst affected room. This can be achieved by following a path back-and-forth across the room (following a “lawn-mowing pattern”) whilst either recording audio (for subsequent analysis), by averaging an FFT analysis over the whole room or (if appropriate as above), averaging the 1/3 octaves over the room.

2. Non-tonal LFN?

Does the complainant hear the LFN in all rooms or is it much worse in one room? LFN tends to pass through windows and through the roof directly above a room rather than through walls. The answer can provide a clue as to the potential direction of the LFN e.g. if the noise is worse in the ground floor front rooms of a house and in the bedrooms above, then the source is probably not at the rear of the dwelling.

1/3 octave measurements should be made in the worst affected room.

3. Internal or external noise source?

Based on the above measurements, if it is suspected that the LFN is caused by an internal noise source within the dwelling, where practical, turn off potential sources and repeat the relevant subjective and objective evaluations.

Where this is not possible (e.g. blocks of flats), then a useful approach is to measure the noise at locations outside the premises using the same parameters as for the internal measurements. Comparing the difference in level with the expected attenuation through a window at the relevant frequencies can also provide evidence for an external noise source.

4. Noise or vibration?

Internal or external vibration can be radiated as LFN within a building. Complainants will often suggest that the problem is vibration because the windows move when the issue is actually LFN that vibrates the glass. In either case, the evaluation process is the same. Carry out the analyses as per step 1 and 2 above and then repeat outside at several meters from the building.

As significant levels of vibration induced noise are unlikely to be detected outside the building, if LFN is detected outside, it is evidence that the LFN is airborne noise and not vibration.

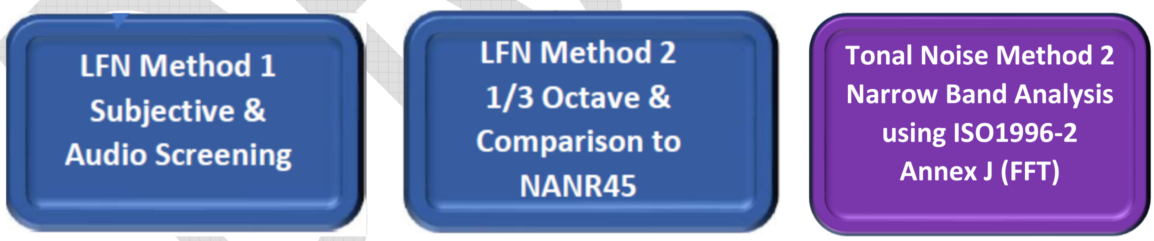
9.2 LFN Assessment

A low frequency noise investigation protocol recommends investigators to assess the history including:

- When the LFN was first heard;
- They type of noise, its duration and frequency;
- The complainant's belief about the source;
- The effect of the noise on the complainant;
- Whether other family members hear it;
- Whether neighbours hear it;
- Whether the complainant believes they are particularly sensitive to other sources of noise.

The surveyor should initially try to listen to the noise, (but being aware that there is a substantial variation in hearing acuity at low frequencies from person to person), then measure and assess the noise. The surveyor should then try to locate the source and where necessary take appropriate action to resolve the problem. In many situations, however, the identification of the source of LFN alone can prove to be hugely problematical.

Three methods to investigate if LFN is present are provided in this section, one of which is already outlined in Section 8.2.



9.3 LFN Method 1. Subjective Audio Screening

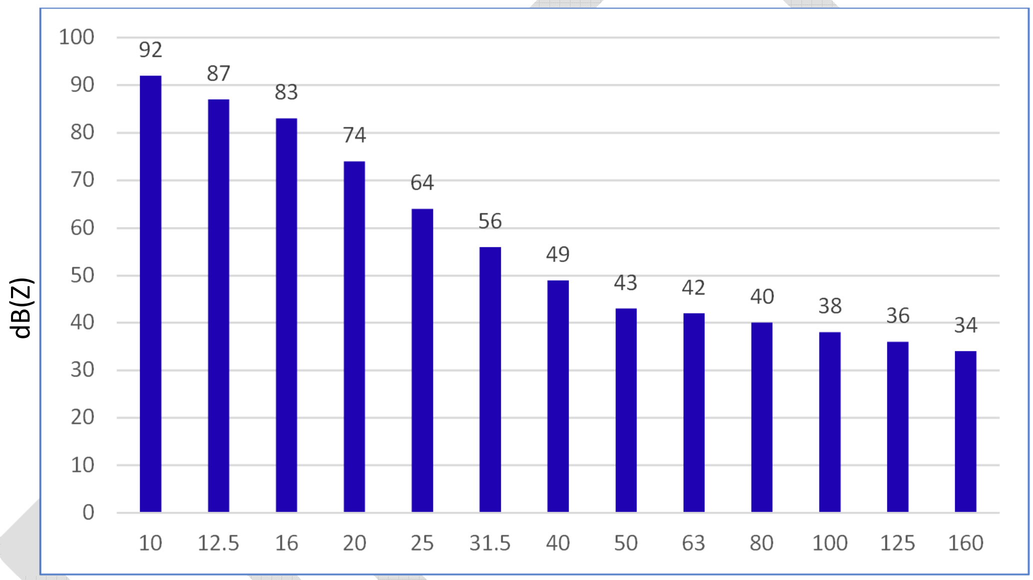
Whilst it is often not necessarily possible to hear LFN and the person taking the measurements may not be able to hear it on-site, a useful technique is to record the sound using a sound level meter. Using noise analysis software (including freely available open source PC programmes such as Audacity), this audio can then be replayed at a multiple of normal speed to shift the frequency higher. For example, replaying a 30Hz tone at x5 speed creates a tone at 150Hz that can easily be heard. The same applies to any sound with character, e.g. with a varying level. This technique can be used as a subjective screening method to assess if LFN is present in the noise recordings.

9.4 LFN Method 2. 1/3 Octave Measurement (NANR45)

NANR45 recommends that in the first instance, the nose levels in the room where there is a complaint of low frequency noise, should be measured. The sound level meter should be set to linear and the L_{eq}, L_{10} and L_{90} acoustic parameters should be measured over the frequency range of 10Hz to 160Hz in 1/3 octave bands. If the L_{eq} values measured over a time when the noise is said to be present exceeds the values in Table 7, also shown in Figure 18, then low frequency noise is said to be audible and could cause disturbance.

Note that the values in Table 7 & Figure 18 should be used with caution, as it has been found in practice that the noise level may not exceed the values in the table in all cases for it to be audible by some and further investigation by narrow band frequency analysis should be conducted as per Tonal Noise Method 2.

Figure 18. Threshold of Hearing for 1/3 Octave Band Centre Frequencies



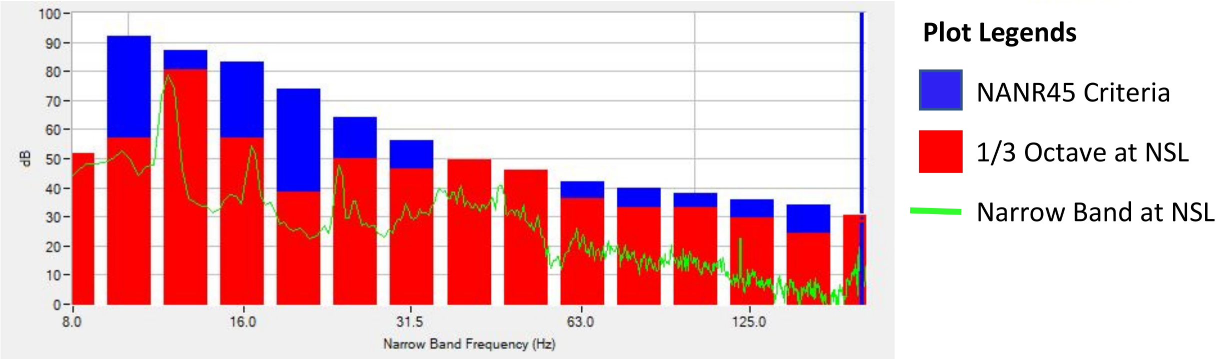
If the measure noise level - L_{eq} dB(Z) - by 1/3 Octave analysis exceeds the noise levels shown in Figure 18, then LFN is present.

9.5 Tonal Noise Method 2. Narrow Band Analysis (FFT)

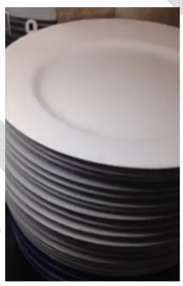
Narrow band frequency analysis using Tonal Noise Method 2 should be conducted at the complainant's property to identify any tonal peaks in the frequency range of 10Hz to around 200Hz (and sometimes somewhat higher). This is the preferred method for low frequency tonal noise identification, as shown in the example in Figure 19, which demonstrates a LFN assessment at a complainant's property (NSL).

The 1/3 octave noise levels at the property are also overlaid with the NANR45 criteria as outlined in LFN Method 2. According to this analysis, only the 40Hz and 50Hz 1/3 octaves should be audible as they are the only two frequencies that exceed the threshold of hearing value of 49dB and 43dB respectively at these frequencies.

Figure 19. LFN Investigation by Narrow Band Frequency Analysis



However, Figure 19 also shows 1/3 octave tonal noise at 12.5Hz but the overall noise level at this frequency is under the threshold of hearing according to NANR45 so should not be audible. This is why this method should be used with caution in LFN investigations and in combination with narrowband frequency analysis, which should always be conducted. The narrow band signature (green line) is overlaid with the 1/3 Octave data and it identifies a large tone at 11.8Hz that was the cause of extensive complaints.



In cases where LFN is tonal, it is usually possible to identify the source(s) by matching the frequencies of the tones to particular sources (on the complaints property or off site). In the example given, the noise source was traced to a large vibrating screen/hopper running at 11.8Hz. This caused plates and doors at the complainant's property to rattle due to the pressure pulsations, rather than the direct noise from the hopper. (See https://youtu.be/f_bAlh1xAuM & https://youtu.be/emK5eGvxfzs)

In this example, as the source had been identified, it was then possible to develop engineering source control modifications that eliminated the issue. Note that conventional noise control methods such as acoustic absorbent, noise barriers and silencers are not effective at low frequencies.

The presence of this low frequency tone from a licensed facility at night time would be a non-compliance with the licence. A penalty of 6dBA for this tone would be appropriate, where it arose from a licensed facility during the day or evening time.

This example shows that narrow band frequency analysis of LFN, combined with other methods outlined is imperative to get to the root cause of the problem and alleviate complaints from difficult to identify low frequency noise issues.

10.0 IMPULSIVE NOISE & OTHER SOUND CHARACTERISTICS

Noise that has impulsive characteristics can cause annoyance. Other sound characteristics e.g. intermittent noise and animal vocalisations in certain settings (e.g. abattoir) can also cause annoyance. Impulsive and other sound characteristics are discussed in this section along with adjustments/penalties to be added to the measured L_{Aeq} if present.

An impulsive noise may sometimes exist at such a low level that it would be acceptable to sensitive receptors and would be unlikely to cause any disturbance or annoyance. To require a complete absence of impulsive noise in such cases may be impractical and of little benefit.

Impulsive noise is sound with a sudden onset. A noise source that attracts an impulsive characteristic will often be described as something with a thumping, banging or impact noise that is clearly audible above everything else. It is distinguished by a sharp rise in noise level. Some examples include the noise from a heavy mechanic press that consistently produces an impact noise as it stamps out a metal template, the noise from the dropping of material that causes a short burst of loud sound as the material hits the ground or the noise of heavy hammering and banging from a workshop area.

An impulsive characteristic would not be applied to a noise that simply varies in level. A short burst or impact, or series of impacts, need to be present in order to apply the impulsive characteristic. The duration of a single impulsive sound is usually less than 1s. ISO 1996-1 identifies impulsive sound sources of different magnitudes, as summarised in Table 8 and some additional sources mentioned in ISOPAS 1996-3:2022 are also included in the table.

Two methods to investigate if impulsive noise is present during a noise survey investigation are provided in this section. Method 1 is a subjective method and Method 2 is an objective method. Two standards are reference for the objective method, as both are similar and either can be used in a noise survey investigation.

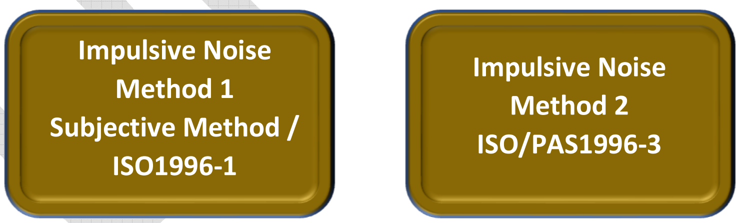


Table 8. Impulsive Sound Sources

Magnitude	Description	Examples
Regular impulsive sound sources	Impulsive sound sources that are neither highly impulsive nor high-energy impulsive sound sources. Note this category includes sounds that are sometimes described as impulsive, but are not normally judged to be as intrusive as highly impulsive sounds	➢ Slamming of car door ➢ Outdoor ball games, such as football (soccer) or basketball ➢ Church bells ➢ Very fast pass-by of low-flying military aircraft ➢ Goods delivery ➢ Fork lifts with rattling forks ➢ Skateboard ramps
Highly impulsive sound sources	Any source with highly impulsive characteristics and a high degree of intrusiveness	➢ Small arms fire ➢ Hammering on metal or wood ➢ Nail guns ➢ Drop-hammer ➢ Pile driver, ➢ Drop forging ➢ Punch presses, ➢ Pneumatic hammering ➢ Pavement breaking, ➢ Metal impacts in rail-yard shunting operations ➢ Compressed Air Release, ➢ Scrap Handling ➢ Industrial shearing, gas discharges ➢ Percussive tools in demolition ➢ Powered riveting
High-energy impulsive sound source	any explosive source, or sources with comparable characteristics and degree of intrusiveness	➢ Quarry and mining explosions, ➢ Sonic booms, ➢ Demolition ➢ Industrial processes that use high explosives, ➢ Explosive industrial circuit breakers, ➢ Military ordnance (e.g. armour, artillery, mortar fire, bombs, explosive ignition of rockets, and missiles.

10.1 Impulsive Noise Method 1. Subjective – ISO1996-1

Normally an impulsive characteristic is determined subjectively based on its audibility and prominence where it has a clearly sudden onset and of a type listed in Table 8. Note this table is not exhaustive and there are other noise sources not listed that may be considered impulsive during a noise survey by the competent person.

The presence of impulsive noise at a noise sensitive location should be noted by the surveyor during a noise survey and a determination as to whether the noise can be attributed to the licensed site. Multiple observations of the sound should be made. Analysis of audio from a noise survey after the event can also be used to determine the presence and frequency of impulsive noise and this is particularly useful for long-term measurement surveys. Examination of the noise spectrum graph for the monitoring period may also indicate periods where impulse noise is present and some acoustic software may also identify impulsive noise events.

10.2 Impulsive Noise Method 2. ISO/PAS1996-3

An objective method for the analysis of impulsive noise is provided in ISO/PAS 1996-3:2022.

For the objective determination of impulsive noise, the standard requires the assessment of the A-weighted sound pressure levels with time weighting F, to determine the:

- L_{AFmax};
- Level Difference - the difference in dB of L_{pAF} between the level of the end point and starting point of the onset of the impulsive noise;
- Onset Rate - the slope in dB/s of the straight line that gives the best approximation to the onset of impulsive noise;
- Prominence – calculated from the level difference and onset rate;
- Adjustment factor K_I – calculated from the prominence factor.

A-weighted frequency is generally used to assess all impulsive sound sources except high-energy impulsive sounds, where the fundamental descriptor is the C-weighted sound exposure level L_{EC} as per Annex B of ISO1996-1. For impulsive sounds with strong low frequency content, the unweighted/linear dB(Z) is used.

The assessment time interval for impulsive noise is generally over 15-30 minutes. However, for assessments with short-duration reference time intervals, shorter assessment time intervals may be more appropriate.

The objective method can be undertaken manually by the competent person or alternatively many commercially available software packages are able to automate this method.

10.3 Impulsive Noise Penalties

If impulsive noise is present at a noise sensitive location, then the competent person may assign a penalty adjustment subjectively as per ISO1996-1 as follows:

- Regular impulsive sound sources – 5dB adjustment penalty
- Highly impulsive sound sources – 12dB adjustment penalty
- High energy impulsive sounds - the adjustment depends on the C-weighted sound exposure level L_{EC} level.

This is to be determined on a case-by-case basis at each noise sensitive location and the subjective method may be used in the majority of cases where impulsive noise is clearly audible. However, where there is any dispute as to the presence of impulsive noise at a licensed facility, the objective method should be used.

The objective determination of impulsive noise calculates the adjustment factor K_I, which can be applied directly to the measured noise level, or it may be used to categorise the impulsive sources into either regular impulsive or highly impulsive sources, from which you can apply the penalty indicated in ISO 1996-1.

Licence conditions typically specify that there shall be no clearly audible impulsive component at a noise sensitive location at night time. Therefore, the presence of a clearly audible impulsive noise is a non-compliance with the licence conditions, even when the night time noise level is under the limit value. Where complaints are issued regarding impulsive noise, further investigation is warranted to diagnose if the licensed site may be causing the impulsive noise and if this is found to be the case, then noise control measures need to be implemented, where appropriate (Section 13).

If more than one adjustment is potentially applicable for the type or character of a given single sound source (i.e. a source that is both tonal and impulsive), then both adjustments shall be applied.

While all licensed facilities should use BAT to eliminate and control impulsive components, it may be impractical to always completely eliminate some of these characteristics. At night-time, however, there should be no clearly audible impulsive characteristic to the noise at any NSL. In addition, adjustments for impulsive character should only be applied to impulsive sound sources that are audible at the receiver location.

When the sound produced by an impulsive source is so low that it cannot be separated from the sounds produced by other sources or the impulses are so infrequent that they do not affect the result, then these impulses should not be considered.

10.4 Intermittent Noise

Noise that stops and starts at irregular or regular intervals is considered to be an intermittent noise and its presence can cause more disturbance that a steady state noise. Two methods to investigate if intermittent noise is present are provided in this section.

10.4.1 Intermittent Noise Method 1. Subjective

Similar to impulsive noise, an intermittent noise can be determined subjectively if it is clearly audible and occurs at regular intervals and is present during the noise survey duration. Where intermittent noise is considered to be the source of a noise problem on a site, but not present or audible to the surveyor during a typical attended annual noise survey, then a long-term noise survey may be appropriate. Correlation of information on when the noise source was on (from the site or a complainant) and the data collected for that time-period can assist in the determination of a potential noise source. Note that intermittent noise that is tonal in nature and/or low frequency may not be clearly audible to the surveyor, so analysis of audio data collected from a survey is imperative to determine the acoustic characteristics at the noise sensitive location.

In order to assist with the subjective determination of intermittent noise, the site or complainant may be able to record the noise (on a smartphone) in the absence of extraneous noise (traffic etc), which can then be referred to an acoustic specialist. This method is to be used for investigation purposes only and audio recordings from a complainant will not be used for compliance assessment. Assessments made by the acoustic specialist or inspector using calibrated instruments following standard methods will determine the presence or absence of intermittent noise and the correct way to deal with it.

10.4.2 Intermittent Noise Method 2. BS4142: Section 7

The objective evaluation of intermittent noise that may be used by the competent person is detailed in Section 7 of BS 4142:2014+A1:2019.

Intermittent noise is evaluated as part of an assessment by using the on and off time period noise levels to correct the site specific L_{Aeq}. i.e. comparing the measured noise levels to the information from the site as to when equipment was on and off. The measurement of intermittent noise may require extended measurement periods depending on whether it is cyclical, intermittent or varies randomly. Even when long-term measurements are undertaken, this may not provide an accurate objective indication of the subjective effect. This is particularly the case for intermittent sources that generate tonal noise. An example of this would be a chiller where the fans and/or compressors cut in and out or vary in speed rapidly depending on the load. It should be noted that there should be no clearly audible intermittent tonal or impulsive characteristic to the noise at any NSL at night-time.

All licensed facilities should use BAT to eliminate and control intermittent components.

10.5 Other Sound Characteristics

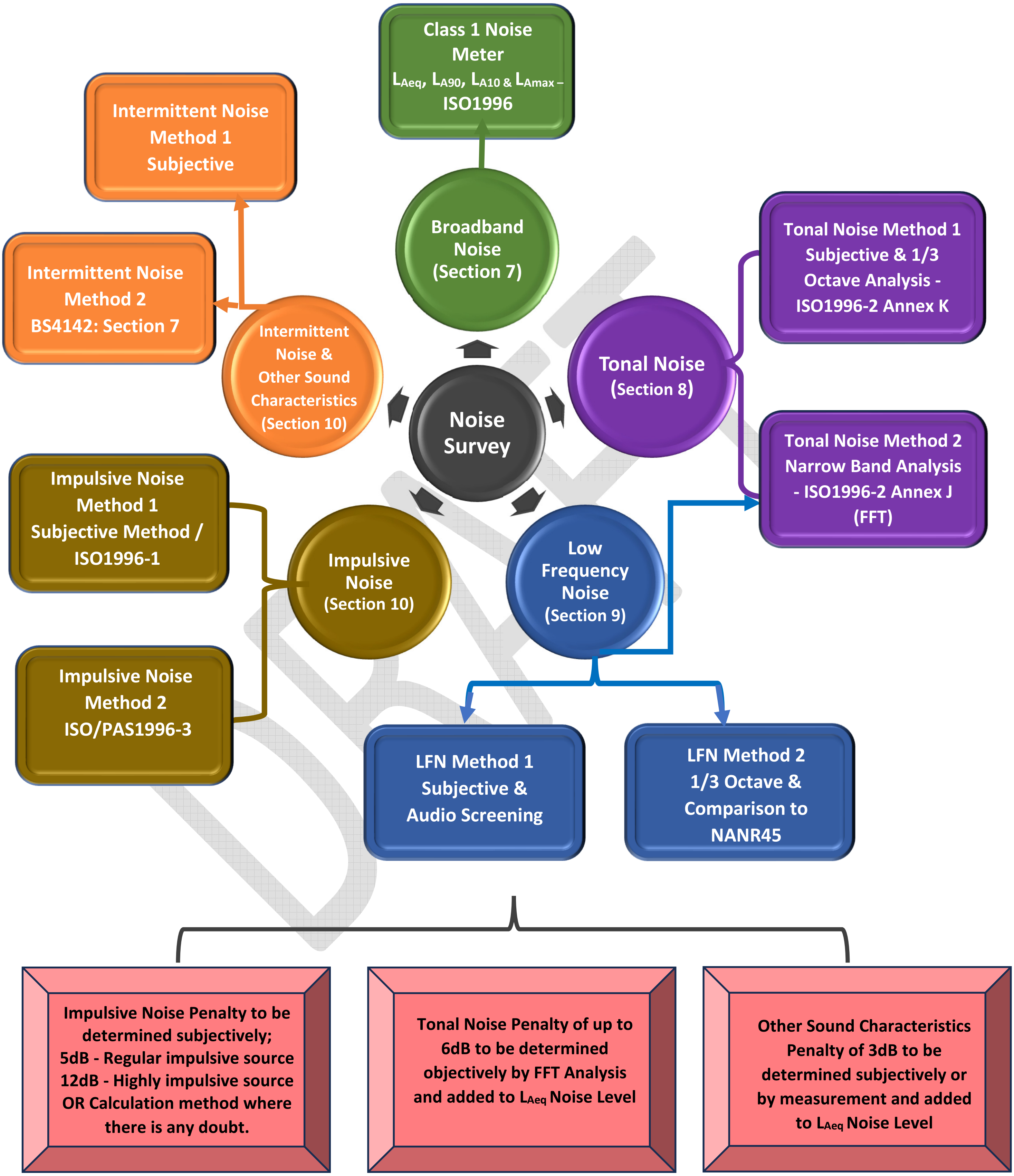
BS4142 refers to “other sound characteristics”, which are neither tonal, nor impulsive, nor intermittent, but are otherwise readily distinctive against the residual acoustic environment at a noise sensitive location. BS4142 states that a penalty of 3 dB can be applied where these characteristics are present.

A relevant example of “other sound characteristics” could be certain animal noises, e.g. pigs squealing within a licensed facility that are audible outside the boundary. The identification of other sound characteristics should be determined by the competent person. Although animal noises may come under the definition of “other sound characteristics”, some may also be categorised as impulsive or tonal by the competent person, depending on the circumstances.

It is also important to bear in mind when assessing sound characteristics and penalties to be applied, the subjective impact on a complainant is often greater than an objective measurement or an initial subjective evaluation might indicate. For example, whilst impulsive bird song and pig noise may have similar characteristics, tonal content and impulsivity, there is human “responsibility” attached to the sound from pigs that renders it substantially more objectionable. It is noted that there should be no clearly audible tonal or impulsive noise at any NSL at night-time. In addition, when assessing other sound characteristics, the competent person should consider whether any noise is so loud, so continuous, so repeated, of such duration or pitch or occurring at such times as to give reasonable cause for annoyance to a person.

For clarity, a summary of all recommended methods that may be used during a noise survey investigation and penalties to be applied, as indicated in the previous sections is provided in Figure 20.

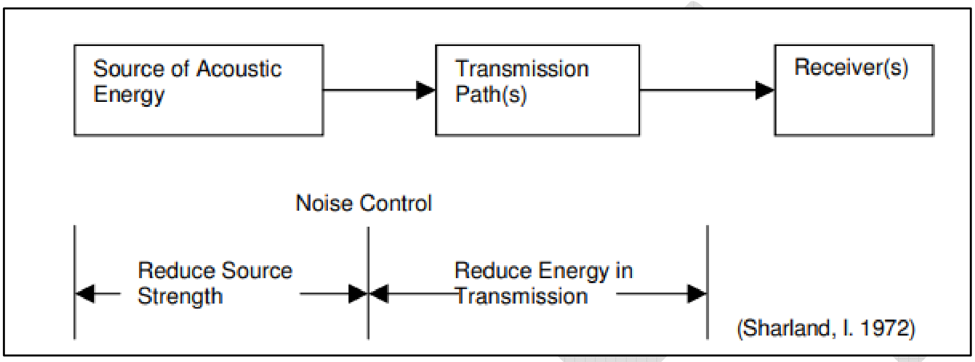
Figure 20. Summary of Noise Survey Investigation Methods and Penalties



11.0 NOISE MANAGEMENT PLANNING

The control of noise from a licensed site is managed by early planning to identify if noise that is liable to cause annoyance may occur and also by correctly diagnosing it where it already exists. Once noise sources are identified then it is possible to reduce the source strength or impede the acoustic energy along its transmission path, to ensure the site complies with BAT for noise control, as shown in Figure 21.

Figure 21. Noise Management using Source-Pathway-Receptor Model



- Planning for Noise
- Noise control at source using BAT
- Noise control of pathway using BAT
- Site Complies with Licence Conditions

Note that some licences may have conditions regarding the requirement for a Noise Management Plan, as indicated in Section 5.1. This section outlines methods to manage noise from a licence facility by planning and diagnosis of noise sources, which will allow the licensee to devise a Noise Management Plan specific for their site. Details on BAT noise control measures that may also be required for the Noise Management Plan are provide in Section 13.

11.1 Framework for Noise Control & Mitigation

The mitigation or amelioration of the degree of environmental impact is a prerequisite for a wide range of emissions. Mitigation measures can be broadly classified into avoidance (i.e. using an alternative approach to eliminate an impact) or reduction (reducing the severity of an impact). Environmental mitigation measures may include any of the following:

- Process alterations to reduce emissions;
- The installation or alteration of control equipment;
- Restricting the hours or intensity of operation of a plant, and;
- Modifying site or plant layouts, discharge points etc. to reduce the impact of emissions.

1.0 Mitigation measures themselves can occasionally have secondary impacts and these need to be identified and evaluated before implementation (e.g. fitting an acoustic attenuator or other control mechanism may impact the performance of certain equipment or may result in reduced energy efficiency).

The identification and application of mitigation measures should be considered during the planning and/or environmental impact assessment stage of a project. In many instances however, there will be a requirement for ongoing management and control of noise over the lifespan of the site.

At some sites a combination of factors (e.g. inherently quiet plant or activities and/or effective containment of noisy sources) ensures that environmental noise is a relatively minor issue and significant noise impacts are unlikely to arise. However, many plants will require an ongoing programme of work to ensure an effective level of control over the facility's noise emissions. To this end it is considered appropriate that a Noise Management Plan be adopted for most sites based on a risk assessment approach. The factors addressed in this guidance relating to the absolute noise level and the presence of acoustic characteristics will help to determine the nature and extent of the Noise Management Plan. The degree of attention and priority that the plan will require will also be determined on a site-specific, risk assessment-based approach.

The majority of sites can be categorised as Low Risk or High Risk with regard to noise. The degree of risk is based on the examination of noise sources on-site and noise propagation factors, along with a review of monitoring data and complaint history. An indication of some of the pertinent factors to determine if a site is low or high risk is presented in Figure 22. Rather than serve as a rigid tool for classifying each site, the schematic should be used to assist licensees and enforcement officers to assess the level of risk.

Figure 22. Noise Management Plan Risk Assessment Criteria

Low Risk Site

Noise Management Plan Not Required

- Always complies with licence limits.
- Noise is broadband in nature, with no tonal, low frequency, impulsive or other sound characeritics
- The rating level is no more than 5dB above background (L_{A90}) noise levels.
- There have been no justifiable noise complaints.
- Noise sensitive locations are well screened or remote from the dominant noise sources.

High Risk Site

Noise Management Plan Required

- Does not always comply with the relevant day, evening and night time criteria associated with the operation.
- Tonal, low frequency, impulsive noise or other sound characteistics are audible
- There is a history of justifiable noise complaints
- There is no history of noise complaint, however, development trends indicate that new noise sensitive receptors may be established near the site.

Even when a site is considered to be low risk with regard to noise, ongoing management of noise is required at licensed facilities. In this regard it is noteworthy that in many instances the installation of new plant, such as atmospheric abatement, air handling equipment or waste management plant, may give rise to significant new noise emissions. Therefore, many plants will require an ongoing programme of work to ensure an effective level of control over the facility's noise emissions, which should be documented in the Noise Management Plan.

A Noise Management Plan can be included in the overall Environmental Management System for the site, whether this be a certified system like ISO14001 or an in-house EMS, required under the licence.

11.2 Planning for Noise

The issue of noise should be considered as early as possible when planning or modifying a site. If potential noise impacts are identified early enough, it may be possible to address these by designing the site in such a way as to use non-sensitive buildings to screen noisy items of plant from sensitive receptors. Failing this, the selection of quieter processes and equipment with inherently low noise output may obviate the requirement to employ proprietary noise control techniques.

If the impacts cannot be sufficiently ameliorated through careful zoning and equipment selection, it will be necessary to employ other forms of noise control. The comparison of calculated/modelled noise levels at noise sensitive receptors with the relevant limit values and the assessment of tonal, low frequency and impulsive noise elements will confirm the extent of noise reduction that is required. Noise modelling can also be used to inform decisions on the impact a site is having at NSLs. Consideration may then be given to the optimum form of noise control, which may necessitate treatment to the source(s) of noise by engineering modifications or the use of secondary measures such as enclosures or barriers.

Notwithstanding the need for comprehensive assessment and the application of proven noise control techniques, note that effective planning and management also calls for common sense and good practice. Some important points to bear in mind include:

- Where feasible, noise should be controlled in the planning and/or implementation of activities. This can be achieved by altering site/plant layouts, suitable work practices and the selection of quiet plant and machinery;
- Where unavoidably noisy and/or directional plant is used, this should be positioned as far away from sensitive receptors as possible. Where possible, make use of site buildings to screen the source of noise;
- Group noisy items of plant together, perhaps reducing the noise control burden and/or reducing the number of locations where measurements are required;
- Where potential noise issues are likely to arise, good acoustical design and practice at the outset should be encouraged;
- Where feasible, particularly noisy operations should not be permitted during night-time hours or in the early part of the morning in situations where an off-site impact is likely;
- Ensure that existing noise controls are effectively operated e.g. keep doors and windows to noisy process areas closed, ensure that cover-plates and acoustic hoods/enclosures are properly fitted and tightly sealed when plant is operating;
- Staff training and awareness may in some instances be the critical factor in maintaining control, e.g. by avoiding excessive revving of machinery, minimising

impact noise and by switching off noisy equipment when not in use.

- Most machinery and equipment runs quieter when in good condition and properly adjusted. When poorly maintained, noise levels could be up to 10 - 20dB L_{pA} higher.
- Poorly maintained noise control hardware does not function as well, and;
- Establish an ongoing and evolving programme of noise level measurement and noise control.

In some jurisdictions, proactive planning and development policies zone land banks for industrial or residential use. Such an approach permits the use of buffer zones to ensure that incompatible land uses do not encroach upon each other. In certain situations, however, new dwellings may be constructed in close proximity to pre-existing industrial or waste management facilities and this can cause potential difficulties, as many licences specify a noise limit to be achieved at all NSLs. Facility operators should therefore be aware of any future planning in the vicinity of their sites. The existence of a facility prior to the introduction of NSLs into its vicinity does not provide any allowance for non-compliance with appropriate noise limit values.

It is also considered that relevant local authority planning departments should require that parties applying for such one-off developments should consider the issue of noise in a robust manner early in the planning process to avoid issues arising once these sites are occupied. This would typically fall under the remit of a competent person.

11.3 "Buy Quiet" Environmental Noise Purchasing Policy

When plant is due for replacement or modification, noise should be one of the fundamental considerations. Organisations should consider implementing an environmental *Buy Quiet* noise policy that includes noise specifications that must be met at various locations off-site and that can then be used to determine the specific noise specifications for individual items of plant.

This is probably the single most cost-effective long-term noise control measure that a company can take – provided that both suppliers and other relevant engineers have used the best practice diagnostic process detailed in Section 11.5 to determine what constitutes best practice.

It is important to note that many suppliers may not have significant expertise in noise control and may propose mitigation measures that are not best practice. This can result in noise control measures that are unnecessarily costly or that are not sufficiently effective.

The policy should include:-

- Noise specifications for each item of plant, including overall dB(A) level plus octave band and tonal frequency requirements and details of sound power level (L_w or SWL).
- Details of the noise data required, including narrow band information to determine if there is tonal content. Measurements should be taken using a calibrated SLM at a similar installation by the supplier and/or competent person/consultant. If this is not available, then you must assume that the noise is tonal and apply a penalty unless

the supplier can provide a guarantee that there is no tonal content. Note: a simple option that can be used to establish if the noise is tonal is to ask the supplier to provide a smartphone spectrum analysis or a video clip of similar plant in operation somewhere else. This can then be used to determine if tones are likely. This is not a standard method, but may be the only practical way to acquire the required data from suppliers for the assessment of equipment prior to purchase.

- The details of any proposed noise control measures.
- The diagnostic procedure that was used to justify any suggested noise control measures.
- A review of the current state of the art noise control BAT for the particular plant or processes in question and why they have selected the proposed mitigation option.
- An assessment on the impact the proposed plant will have at noise sensitive locations close to the site.

11.4 Maintaining Low Noise Levels

Plant maintenance is often a key component in any noise management plan. Most machinery and equipment is quieter when in good condition and well maintained. Table 9 outlines a few common plant elements that can created noise problems due to faults that should be rectified by maintenance or modifying procedures.

Table 9. Common Maintenance Issues Leading to Noise Problems

Fault	Noise Problem
Worn bearings	Tonal Noise
Out-of-balance (particularly fans)	Low frequency hum
Silencers	Internals can become clogged or corroded away, rendering them ineffective. They may require cleaning or replacement.
Enclosures	Left open due to access difficulties rendering them ineffective
Poor adjustment on conveyors or vibratory plant	Unnecessary rattles or impacts
Doors or windows left open at night	Higher noise levels

11.5 Diagnostic Noise Control Process

When it has been determined by noise assessment that noise control is required at a site and noise control at source is practical, this may be the most cost-effective approach to solving the noise issue. Ideally, alternative mitigation methods that reduce the transmission of noise, such as enclosures, barriers, lagging and silencers should be considered as a secondary option when control at source cannot offer a complete solution. The diagnostic process to assist licensees consider the BAT noise control measures is provided in this section. When this method is followed, the optimum combinations of source and alternative control methods can be determined.

The available options for Noise Control are:

- Source control – multiple engineering options;
- Silencing - conventional and unconventional attenuators;
- Vibration isolation to prevent vibration transmission to noise radiating surfaces;
- Vibration damping of noise radiating surfaces;
- Acoustic enclosures - including lagging;
- Noise barriers.

All the noise control options available with the best of current technology must have been considered in order to ensure that BAT has been used. The key question is how to determine which options are most applicable to a particular noise problem. This can be done by undertaking a diagnostic noise source process on all relevant noise sources to eliminate guesswork. Where there is tonal noise, this process should include narrow band frequency analysis to identify sources.

The following eight steps are provided to assist in the diagnosis of noise on a site and to determine what control measures to implement. These are recommended steps when determining the optimum mitigation options. In the steps outlined, examples are provided for compressor noise, cooling tower noise and noise from induced draught (ID) fans on boilers, as these items of plant commonly lead to noise complaints. However, there may be many other specific noise sources on a site, identified by the competent person during a noise survey investigation that require consideration in the diagnostic process.

Step 1	**Identify contributory site noise sources and their characteristics (following the methods outlined in Sections 8-10)**
	• *Compressor - look for low-frequency hum* • *Cooling tower - typically generates broadband noise* • *ID fan - can have a fan tone and broadband noise from stack*
Step 2	**Rank these sources – both in terms of dB(A) and character at one or more NSLs, near complainants, at the site boundary or other reference position**
	Source ranking: • *1. ID fan* • *2. Compressor* • *3. Cooling tower*
Step 3	**Identify all potential noise sources within the dominant machine / process identified in Step 2 above**
	ID fan: • *Mechanical noise from fan drive;* • *Broadband fan noise via stack;* • *Tonal fan noise via stack;* • *Duct vibration*
Step 4	**Rank the sources in the dominant item of plant by subjective effect – dB(A) and character**
	ID fan • *1. Tonal fan noise via stack – must be mitigated* • *2. Broadband fan noise via stack – no need to mitigate* • *3. Mechanical noise from fan drive – no need to mitigate* • *4. Duct vibration – no need to mitigate*
Step 5	**Repeat 3 and 4 for the next most dominant sources, e.g.**
	Compressor *1. Low-frequency tonal noise from air intake – must be mitigated* *2. Pressure pipe radiated noise – no need to mitigate* *3. Panel radiated mechanical noise from compressor drive – no need to mitigate* *Cooling tower* *1. Broadband air noise – must be mitigated* *2. Broadband water noise – marginal mitigation requirement* *3. Tonal pump noise – no need to mitigate*

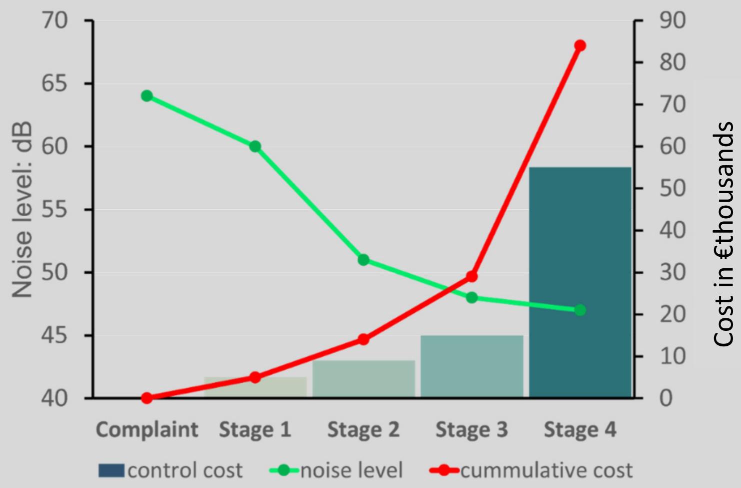
Once this diagnosis and ranking has been carried out by the competent person, noise control engineering expertise will be required to determine the noise control options to achieve BAT.

In the following steps (6-8), options for noise control for the plant diagnosed as contributing to the noise problem are provided, with cost included. Compliance with the licence conditions and BAT (and other relevant legislation if applicable in future) needs to be achieved regardless of the financial cost. The purpose of including cost in steps 6-8 is to show the reader that there may be a large variation in costs for noise solutions identified and traditional abatement options can be more expensive (and less effective) than innovative engineering control of noise at source. In addition, the example shows the balance between the attainment of environmental benefits and the likely cost implications for the licensee, where the cost becomes very high for little or no additional acoustic benefit.

Step 6	Establish and cost the noise control options for the dominant source
	ID Fan Tonal Noise ***Option 1: Aerodynamic noise control. Typical costs: c €10k, downtime 1 day c €15k lost productivity. Total: €25k + no change in running costs*** ***Option 2: Fit large silencer. Costs: silencer c €100k, downtime 2 weeks c €200k lost productivity. Total: €300k + increased running costs due to reduced efficiency*** ***Option 1 saves €280k and no increased running costs***

Step 7	Repeat 6 for the next most dominant sources
	Compressor ***Option 1: Retrofit silencing in existing ductwork. Costs: c €2.5k, downtime 1 day*** ***Option 2 Fit large silencer. Costs: large silencer c €8k, downtime 2 days.*** ***Option 1 saves €5.5k*** ***Cooling tower*** ***Option 1: Retrofit silencer mats + local baffles. Costs: c €20k. No effect on cooling efficiency*** ***Option 2: Fit barriers. Costs: c €28k. Reduced cooling efficiency, increased running costs*** ***Option 1 saves €8k with no effect on cooling***

Step 8	Draw up a schedule of noise reduction benefit v cost as the basis for the optimum Noise Management Plan. In principle, the objective is to be able to generate a cost/benefit trade-off based on current best practice
	The cost/benefit analysis is shown graphically, which outlines cost stages for the options you are considering for noise mitigation, going from low to high costs (stages).



In this example, the Stage 3 noise control measures would likely be considered the point at which no further mitigation would be warranted, as the cost becomes unreasonably high for little or no additional acoustic benefit. This example predicts that the noise level will be reduced from approx. 64dB (do nothing option) to approx. 49dB (with stage 1, 2, & 3 abatement options), which is a significant 25dB reduction (with reductions in tonal/low frequency noise also) at a cost of approx. €25k.

If this facility were to run at night time, additional measures to reduce the noise to the NOISE LIMIT of 45dBA would have to be investigated in the noise management plan. **Compliance with the licence and BAT needs to be achieved (no matter the cost) and cost cannot be taken into account when the licensee may be non-compliant. Non-compliances have to be resolved promptly or further enforcement actions may be taken in accordance with OEE's policy.**

Note that noise control costs vary substantially from project to project depending on factors such as accessibility, lost production costs during downtime etc. The costs provided in this example are indicative only.

12.0 NOISE COMPLAINTS

Noise can cause annoyance and disturbance to people at work or during leisure activities. It can also cause sleep disturbance and have a deleterious effect on general physical and mental wellbeing. People are not equally sensitive to noise and likewise one person is not equally sensitive to noise at all times of the day or days of the week.

Noise is liable to give rise to complaints whenever the level exceeds the pre-existing or background level by a certain margin, whenever it exceeds certain absolute limit values or contains specific acoustic characteristics (tonal, low frequency, impulsive, intermittent or other sound characteristics).

It is important to note that noise emissions are more likely to cause disturbance and/or annoyance during periods when the background noise is relatively low. In this regard, noise complaints are more likely during time periods when receptors are less tolerant of noise (e.g. night-time, weekends, and bank holidays).

In all instances where noise is causing annoyance, the first port of call is to notify the licensee to see if the matter can be resolved. If a licensed site receives a noise complaint, direct from a NSL or the EPA, then all details should be recorded and, in both cases, the matter should be investigated and corrective action implemented where possible to rectify the problem.

In the first instance complaints can sometimes be avoided by proactive and systematic assessment procedures (e.g. identifying when machinery and plant is out of balance) before the impact at a NSL becomes problematic. In some cases, the complaint can be rectified by simple measures like re-locating refrigerated trailers away from residential dwellings, shutting doors or turning off certain equipment particularly during the night time.

The licensee must comply with the conditions specified in the licence relating to the handling and recording of complaints. Once a complaint is made, the following pertinent information should be recorded:

- Name and address of complainant (if complaint is not confidential);
- Time and date complaint was made;
- Date, time and duration of noise and characteristics e.g. rumble, clatters, screeching, continuous or intermittent etc.;
- Details on whether neighbours or other family members have heard the noise;
- Ask the complainant if they would be willing to record and forward a short smartphone audio or video clip that captures the problem noise, which can be later be reviewed by an acoustic specialist;
- Likely cause or source of the noise;
- Weather conditions, in particular wind speed and direction (for intermittent noise sources, especially when the NSL is a considerable distance from the offending noise source, meteorological conditions can be a determining factor), and;
- Investigative and follow-up action arising from the complaint.

Remember that the person working on the site to whom the complaint is made may not be able to hear the noise that is the cause of complaint at the NSL, particularly in low frequency noise complaints. Alternatively, a person working on a site may be so used to a noise source it that it does not cause them distress and these situations can result in noise complaints being dismissed without a full investigation. All noise complaints should be taken seriously by the licensees as the presence of the noise may be impacting the quality of life of the complainant. This is why all complaints need a full investigation after a complaint is made.

In all cases, an investigation should be undertaken promptly and the complainant should be notified in writing of the findings. Details of any remedial work should also be communicated to the complainant along with a timeframe for implementation. Failure of an operator to engage early with a noise complaint can result in further complaints and a situation where complaints become more strident due to a perceived lack of action.

If the matter is not resolved to the satisfaction of the complainant, then the complaint can be issued direct to the EPA and the matter will be brought to the attention of the site for investigation. An environmental noise complaint can be issued online using the dedicated online form on the EPA website. Continuous breach of the licence conditions relating to noise can result in the site being listed as a National Priority Site i.e. a site with poor environmental performance and ultimately can result in further enforcement action, in accordance with the EPA's Enforcement & Compliance Policy.

For sites not licenced or managed by the EPA and where the matter has not been resolved by contacting the site directly, complaints can be made to the Local Authority in whose functional area the site is located. In 2016 the Network for Ireland's Environmental Compliance & Enforcement (NIECE) published the *National Protocol for Dealing with Noise Complaints for Local Authorities* which provides a good summary of how Local Authorities deal with the range of complaints that they receive. It also provides templates for recording and investigating complaints which may be useful for Licensed sites. The Department of the Environment, Climate and Communications has also published *A Guide to the Noise Regulations*, which also provides useful information regarding making a noise complaint.

The onus on the licensee, after a complaint is made, is to determine if the source of the noise complaint audible at the NSL is attributable to the site, and if it is, to implement corrective action. This is achieved using a competent person who conducts a noise survey investigation using the methods outlined in this guidance as summarised in Figure 20, to identify the precise causes of the complaint(s). The objective is to determine if specific noise characteristics (or combinations thereof) are the cause. Note that it is sometimes difficult to elicit the information required regarding which aspect of the noise is the cause of the problem from the complainant, particularly if there is more than one source. Noise diagnostics is a complex procedure and should be undertaken by a competent person.

Once a complaint has been made, the approach outlined in the following sections should be used to assess if the noise level from a licensed facility is exceeding limit values at a complainant's property or more regularly, if any specific acoustic characteristics are present at the complaint's property that can be attributed to activities at the licensed site e.g. tonal, low frequency, impulsive, intermittent noise or other sound characteristics.

12.1 Complaint Cause Evaluation Process

The following steps are recommended to investigate a noise complaint at a licensed facility. Note that if you don't work on the site and are not familiar with the various potential noise sources, spend some time familiarising yourself with the various noise profiles and it is advisable to make audio recordings (ideally calibrated) for further analysis. This will aid with complaint source identification.

1. Review the information provided by the complainant and discuss what they hear (their description) and whether it is worse at certain times or in certain locations at their property. Note that complainants are quite often not able to describe tonal noise.

2. Listen to the sound (if practical). If you know the site plant, you may recognise noise features. If it is not practical (very intermittent or unpredictable) and the noise is described as tonal, ask the complainant if they would be able to provide a short smartphone audio or video recording, taken by them at a time that illustrates the problem noise. Such recordings can be reviewed by the competent person to aid subjective interpretation or for objective tonal analysis to assist with complaint cause identification. An alternative option is to consider installing a noise recorder inside the complainant's premises, which is a specialised calibrated packaged sound level meter. With this recorder, the complainant can press a button on a remote control to start audio recording when they hear the problem noise and in this way the complainant can make date and time stamped calibrated audio recordings of the problem sound for later analysis by the competent person.

3. A competent person should measure, record and analyse the noise at the location the complainant considers to be the worst. This should include overall level parameters and tonal and impulsive analysis. In addition, if the complainant location is indoors, also measure and record outside the property. The external data will be a closer match to source data as the transmission loss of windows etc colours the noise signature (progressively attenuating higher frequencies). Where it is practical to vary the operation of suspect plant (e.g. turn off for a brief period, vary the speed etc), it is extremely useful to be in mobile communication with the site to time and measure the changes.

Once this data has been collected, the next step is to assess all noise features at the NSL and on-site, following the methods outlined in Figure 20 and detailed in Sections 6-10 including where necessary:

1. Overall broadband noise level (dB(A))

If the potential major contributors cannot be turned on and off even briefly, then measure close to the source(s) and predict and rank the contributions at the complaint site, (noting that these measurements should be made at a distance of at least 3 times the source dimension). It may also be possible to compare the overall narrow band noise signature shape with that of each source e.g. there may be a broad "hump" over a specific frequency range.

2. Tonal Noise

Use narrow band analysis to compare the tonal frequencies at the NSL with items of plant. This provides a precise match to confirm the source(s).

3. Intermittent/impulsive noise

Match time v noise level plots for onsite and offsite noise and log the timings of intermittent events. With narrowband frequency data it is possible to correlate events with specific plant.

4. Low frequency noise

Determine presence of low frequency noise using narrow band analysis both on-site and at the NSL.

Using the methods outlined in this guidance, the competent person will be able to diagnose noise complaints associated with tonal or impulsive/intermittent sound, provided appropriate frequency (narrow band) and temporal analyses are used.

Information obtained from the noise survey investigation following a noise complaint is to be compiled in a Noise Survey Report (Table 6) and results assessed against noise limits and relevant conditions of the licence, taking account of tonal and/or impulsive penalties to be applied. The report should provide an overall assessment of compliance with the licence conditions relating to noise.

12.2 Mitigating the Nuisance

Where a noise complaint is justified from the noise survey investigation and attributed to a licensed site, the next step is to rank the noise sources by their contributions to the subjective impact that has caused the complaint(s) as detailed in Section 11.5 *Diagnostic Noise Control Process* and then to prepare a Noise Management Plan as outlined in Section 11, using the techniques outlined in Section 13.

13.0 NOISE CONTROL – BEST PRACTICE NOISE MITIGATION

Methods to control noise, both at source and by reducing the transmission pathway to ensure the noise is not causing annoyance at an NSL are outlined in this section. Information provided in this section, following the analysis and diagnostic techniques outlined in the guidance will allow the licensee to devise and implement a comprehensive noise management plan for their site to ensure that it complies with the licence and BAT.

Noise control options using the best of current technology must be considered in order to ensure that BAT has been used. As new techniques and technologies are constantly being developed, online research is recommended based on the results of the diagnostic ranking process to help to ensure that the latest BAT is included in the options.

The optimum noise control measures, with examples, for ***three specific sources*** that are common causes of noise problems are provided in Sections 13.1-13.3

- Fan Noise
- Vibrating Noise from Sieves, Screens, Conveyors or Separators
- Generator Sets and Other Engines

In addition, ***general noise control*** techniques are provided in Sections 13.4-13.9, that can be applied to a range of noise problems encountered on industrial sites:

- Vibration Damping
- Vibration Isolation
- Enclosure
- Barrier
- Lagging
- Acoustic absorbent treatments to control reverberation

13.1 Fan Noise

Fans are by far the single most common cause of noise complaints about industrial premises and is the primary cause of over 60% of complaints[2], a large proportion of which have tonal content. The following is a list of the most common items of plant that are the cause of complaints and for which fans are often the dominant contributor:-

- Standalone fans, air handling units (AHUs), ID fans, extract fans etc
- Chillers, coolers (mainly axial fans)
- Cooling towers
- Cyclone separators, dust extract, filter fans
- Air conditioning systems, air-source heat pumps
- Paint booths

- Refrigeration plant

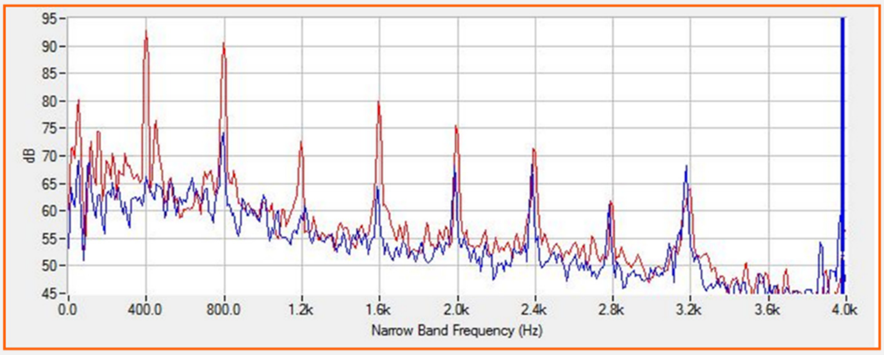
13.1.1 Fan noise – Source Control Techniques

- Controlling fan noise at source simultaneously reduces noise passing through ducts and stacks (both upstream and downstream) and through fan casings. As fans generate the lowest level of noise when operating at optimum efficiency, it is important to consider the following source control techniques where practical:-
- Install fans with 2 – 3 duct diameters of straight duct into the inlet – no bends or dampers in this length (does not apply to non-ducted axial fans).
- Use variable speed drives rather than dampers to control airflow. Fan noise is very sensitive to fan speed.
- Consider if fans can be run at lower speed at night when it is cooler.

The noise from both axial and centrifugal units can often be reduced substantially by using low-cost retrofit aerodynamic fan noise control techniques, particularly when tonal noise is an issue. This is often the only practical solution to attenuate low-frequency fan tones as conventional silencers become increasing less effective (and increasingly large) as the frequency is reduced.

Example 1. Centrifugal Chopper Fan Noise Control

The noise from three chopper fans used to extract and shred scrap aluminium cans caused complaints over a wide area. After diagnosing the problem, aerodynamic fan noise control techniques were implemented that cut the noise by 22dBA despite the passage of cans. The graph shows the narrow band frequency analysis dB(Z) before treatment (in red) and after treatment (in blue). The aerodynamic noise control measures were implemented at 10% of the cost of silencers and lagging, so control of noise at source was the best solution in this case. A sound file to demonstrate the noise before and after noise control measures were implemented is provided if you scan the QR code.

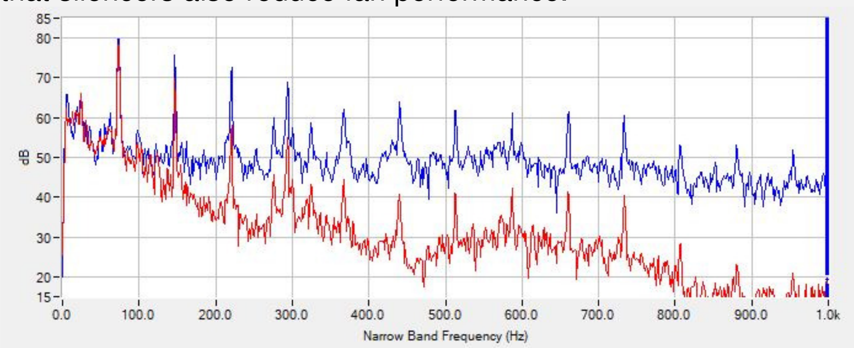


Example 2. Low-frequency chiller and other axial fan noise control

The following example illustrates how low frequency noise is best controlled at source instead of applying standard noise control measures such as silencers, which is typically used in industry. Silencers provide progressively more attenuation with frequency but leave the problem low-frequency tones untouched as this example demonstrates.

Silencer Limitations

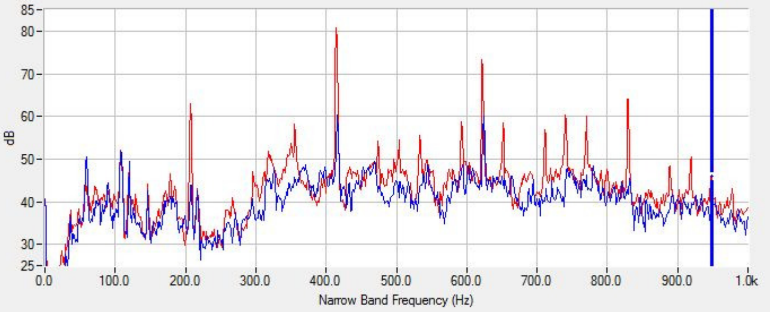
The narrow band frequency analysis provided here is from chiller fans that generate a high amplitude tone at 73Hz and harmonics. A silencer was installed to mitigate the noise from the chiller fans. The blue trace in the graph is the unsilenced fans, the red trace is the fans with a very large, high-performance silencers. The silencers provide progressively more attenuation with frequency but leave the problem low-frequency tones untouched as illustrated in the graph and if you scan the QR code to the sound file. Note that silencers also reduce fan performance.



73Hz chiller fan hum assessed without a silencer (blue trace) and fitted with a conventional silencer (red trace)

Source Control

In this example, the narrow band frequency analysis shows a highly tonal low-frequency (207Hz) noise from axial fans was reduced at source by 20dB using aerodynamic fan modifications that also increased fan performance. The red line shows the narrow band frequency analysis before treatment and the blue line shows the frequency analysis after treatment, with the tones removed. This illustrates that control of fan noise **at source** is more beneficial (and cost effective) than silencers, which provide little attenuation at these low frequencies.



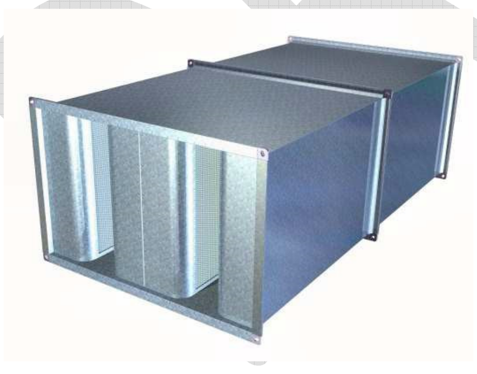
13.1.2 Fan Noise – Control Techniques

Apart from control of fan noise at source, other noise control techniques that are commonly applied include silencers/attenuators, acoustic lagging/lining, louvres, enclosures and barriers. Although these techniques are effective at noise reduction, all have limitations that must be understood by the competent person in diagnosing the noise control techniques required to address the specific noise problem on the site.

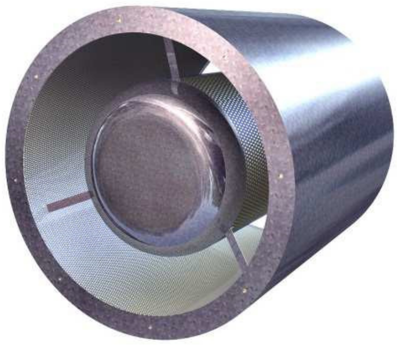
Adding one or more silencers is perhaps the most common fan noise control measure, to control noise transfer along ducts, noise egress from plant exhausts and break-out from plant rooms. They can provide a means of reducing noise transfer whilst still permitting steady flow of air. There are various types, some of which are outlined below. However, the following factors should be taken into account when specifying attenuators:-

- They will only attenuate airborne noise passing through a duct (inlet or outlet), not noise through the casing.
- As 50% of the noise from axial fans in plant like chillers is radiated into the environment from each of the intake and outlet, it may be necessary to attenuate the noise for both paths.
- Consider how much the performance of the fan will be reduced by adding an attenuator and how much the running cost will be increased.

Dissipative attenuators direct the flow of air through passages lined either side with an acoustically absorptive material. The most common variant is the rectangular splitter attenuator, in which the absorption is typically provided by mineral wool behind a perforated metal facing.



Rectangular Splitter Attenuator



Cylindrical Attenuator with Pod

Cylindrical attenuators operate on similar principles to rectangular attenuators. They offer lower airflow resistance than rectangular attenuators although they typically provide less sound reduction than rectangular attenuators of the same length. Performance can be increased by the inclusion of an absorptive module in the centre of the airway, known as a "pod". although this does increase backpressure.

Dissipative silencers attenuate mid-high frequencies, but they generally have poor performance at low frequencies unless they are very long and therefore extremely costly, resulting in high capital and installation costs. Dissipative silencers require maintenance and depending on location they may need to be dissembled and cleaned on a regular basis to maintain performance to prevent clogged surfaces.

Reactive attenuators rely on a “tuned” element to significantly reduce noise transfer over a limited frequency range and as such are primarily of use in respect of fixed speed machinery emitting noise with a highly tonal content. They may be used in conjunction with dissipative attenuators to offer good overall performance. They provide high attenuation, but only over a very small range of frequencies and if the fan speed changes, they may provide no attenuation.

The application of an absorptive lining to ductwork (particularly on bends) and plenum chambers can attenuate sound by dissipative means. The lining typically comprises 25 to 50mm of foam or faced mineral wool. This is a low-cost approach, but it may not provide as much attenuation as employing a proprietary attenuator.

Absorptive Duct Lining

Acoustic Louvres

Acoustic Louvres are effectively a combination of a normal louvre and a dissipative attenuator. They are typically used to provide free ventilation for internal plant rooms and to screen external plant items, particularly at rooftop level. An acoustic louvre is in effect a very short attenuator with a large cross-sectional area, hence the attenuation is very limited. Additional performance can be obtained by placing two louvres back to back, a configuration known as ‘double bank’.

In applications where diagnosis has shown that significant noise is radiated by the fan casing or by ductwork (e.g. scrap rattle in extract systems), then these can be enclosed or acoustically lagged. Note that any acoustic enclosures must be designed to allow for maintenance access and to allow for motor cooling. In addition, lagging ductwork often carries the risk of corrosion from trapped moisture.

For noise attenuation from chiller fans such as this one, acoustic enclosures and barriers are sometimes an effective option, but only if there are no low-frequency tones from the fans (which is a common cause of complaints). Enclosures, barriers and silencers provide negligible attenuation for these tones (often below 100Hz). Moreover, they also reduce chiller efficiency by cutting airflow and hence free-cooling fan speed (and hence noise), so fan speed may have to be increased as a result of this, reducing the attenuation achieved.

Analysis of fan noise before control measures are implemented is imperative as part of the process to determine the optimum noise control solution.

13.2 Vibratory Noise Sources

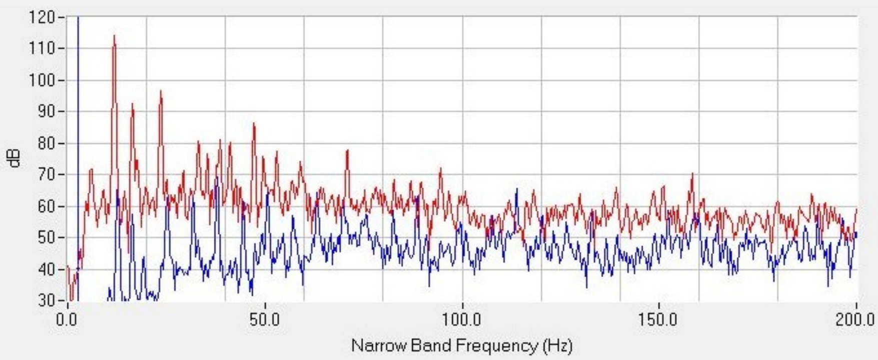
Vibratory Noise sources such as; **Vibrating Sieves or Screens**; **Vibratory Conveyors** or **Vibratory Separators** often generate both low-frequency tones and broadband noise from impacts. Whilst the latter can sometime be reduced at source using high efficiency damping (Section 13.4) and can also be screened using barriers or enclosures, the low frequency tones are much more difficult to mitigate.

For mechanically driven or out-of-balance vibratory systems, maintenance is a very important noise control element as wear in bearings can increase noise levels (including low-frequency components) by an order of magnitude.

The best practice approach to control problem low-frequency tonal noise is based on engineering source control modifications such as vibration isolation (Section 13.5) that require knowledge of the mechanisms and a detailed understanding of noise radiation from the vibrating surfaces. This can be extremely effective as illustrated by this example.

Example 3. Low-frequency vibratory hopper screen noise control

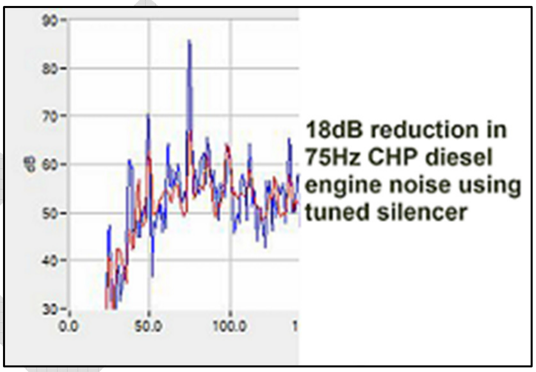
The large vibratory screen in this example caused noise complaints. When narrow band frequency analysis was conducted, the very low frequency vibration @11.8Hz plus harmonics was identified (red line). At this frequency, enclosures or barriers would not be effective. Instead, engineering modifications including vibration isolation and vibration damping were used to reduce the vibration in key components that did not affect operation. The frequency analysis after modification is shown in the blue line, which shows that the low-frequency sound was reduced by 50dB at low-cost and without compromising normal throughput.



13.3 Generator Sets and Other Engines

These include CHP and other installations that include diesel engines. The total noise from these types of plant is generated by different components and therefore each must be considered separate in a noise assessment to determine the best options for noise control. The best approach is to consider the different sources by frequency content, as shown in Example 4.

Example 4. CHP Diesel Engine Noise Control



Noise Source 1 - Engine exhaust: These typically have low-frequency engine firing tonal hum from the exhaust. This can be seen in the narrow band frequency analysis for a CHP diesel engine in the graph, where the blue line shows a 75Hz low frequency tone. The solution is to fit improved, tuned silencers. In the example given, the frequency analysis after the silencer is fitted is shown by the red line, which shows that the tone has reduced by 18dB. Note that these low frequency tones do not usually contribute to the overall dB(A), but they can cause considerable annoyance, as outlined in Section 9.

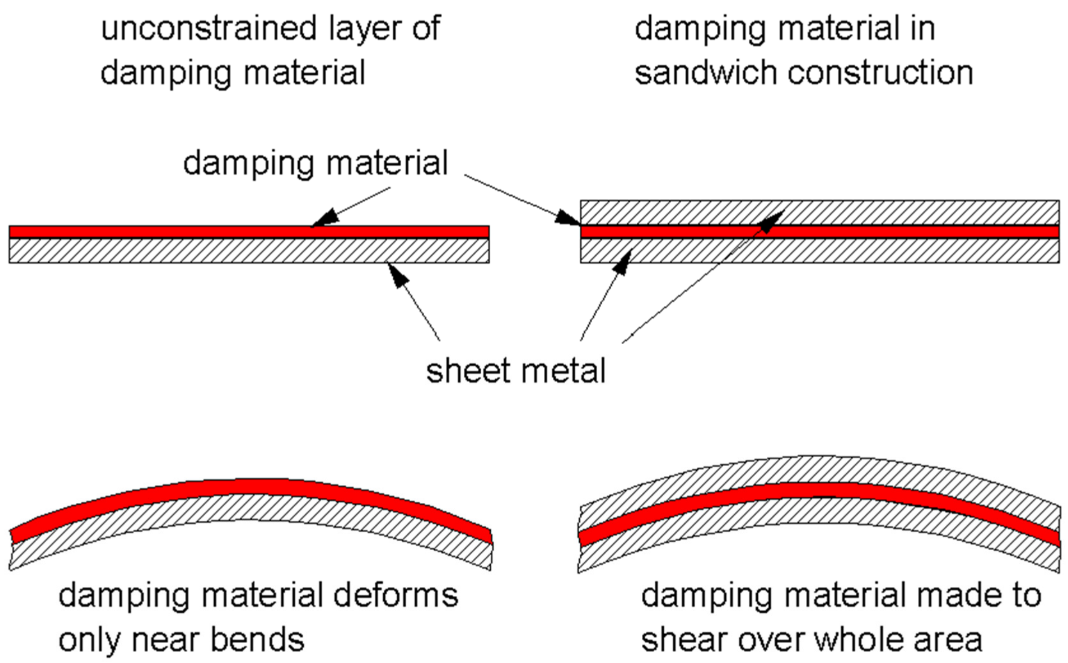
Noise Source 2 - Cooling systems: These comprise engine mounted radiators or remote radiators with fans generating mid-high frequency sound. The fans may sometimes also generate low frequency tones - See Section 13.1 for fan noise control options for this part of the diesel engine plant.

Noise Source 3 - Mechanical noise: This comprises engine and generator noise, which is broadband mid-high frequency sound, usually effectively controlled by the package acoustic enclosure, although added screening may also be necessary in some cases.

The following section provides **general engineering noise control techniques** that are applicable to a wide range of sources.

13.4 Vibration Damping

Noise from mechanical sources is generated by vibration from plant elements and components that is then radiated as sound. Damping materials dissipate vibration energy, reducing the level of vibration and hence the radiated noise.



Not all damping materials are equal. Conventional damping material that is added to surfaces is not durable and has a limited performance. Laminated constrained layer damping is rugged, has higher performance and is low cost.

Creating a highly damped laminate in thin sheet panels can cut the radiated noise by 10dB - 30dB depending on the circumstances. Components can be damped in-situ or the panels can be replaced by proprietary sound damped steel sheet.

Common applications include:-

- Ducting
- Guards
- Enclosure panels
- Any thin panels subject to vibration

Example 5. Chiller Unit Damping Noise Reduction

The thin steel chiller panels on this chiller were laminated in situ to provide damping that reduced panel radiated noise. This was part of a package that reduced radiated noise by 8dB(A).

The sound file illustrates the reduced vibration with the damping installed.

13.5 Vibration Isolation

Vibration isolation involves the prevention of vibration being transmitted from the vibrating source into other parts of the structure that will then behave as “loudspeakers” that radiate the vibration as sound. Fundamentally, it involves placing a resilient element or spring between the source and the receiver.

The spring can be a steel or rubber isolator or compressible pads. The choice depends on the forcing frequency and the application. A key factor that determines the performance of vibration isolation is to ensure that there are no vibration short-circuits where there are rigid connections such as conduits or safety guards that allow the vibration to bypass the resilient isolators.

This water pump is mounted on a concrete base that is then isolated from the surround structure to prevent low-frequency out-of-balance vibration being transmitted into the surrounding structure.

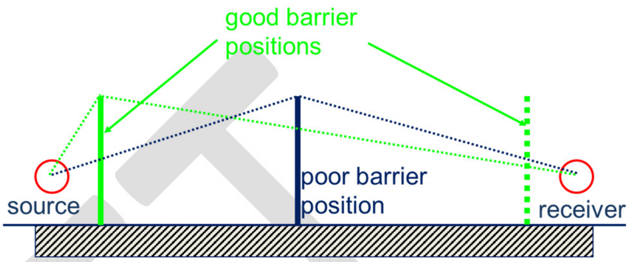
The control of **noise** propagation involves placing a suitable structure in the transmission path between the source and the receiver in order to attenuate the noise.

There are three basic techniques:-

- Acoustic Enclosures
- Noise Barriers
- Acoustic Lagging

13.6 Acoustic Enclosures

These are typically constructed from steel panels (these provide the sound insulation or transmission loss) lined with an acoustic absorbent material (usually faced with perforated steel sheet for mechanical protection). For larger structures, the walls may be concrete or brick.



The structural components (e.g. steel sheet) behave as acoustic mirrors, reflecting and trapping the noise. This means that placing a machine inside an enclosure will increase the noise level of the plant, often by as much as 10dB. Lining the inside of the enclosure with acoustic absorbent prevents this noise amplification, but at the expense of rendering the enclosure highly thermally insulated which can cause problems where motors etc, might overheat.

Consequently, care must be taken to ensure adequate (and silenced) ventilation for cooling. In addition, effective enclosure requires attention to detail with respect to access (sealed acoustic doors), visibility (often double-glazed windows) and any other penetrations.

The overall performance of an enclosure is only as good as the weakest acoustic link. For example, a brick-built, high performance acoustic enclosure for a diesel-powered pump (105dB(A)) with a potential attenuation of 45dB(A) would only reduce the noise by 10dB if 10% of the wall area was an unsilenced ventilation louvre.

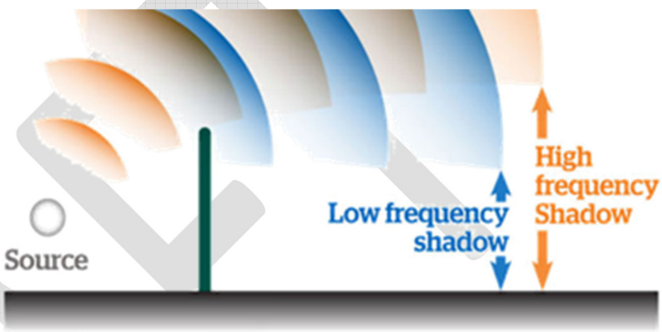
13.7 Noise Barriers

A Noise Barrier is a solid screen (or partial enclosure) placed between the source of noise and the receiver location. This creates a “shadow zone” in which the amount of sound reaching the receiver from the source is reduced. The attenuation provided by the barrier depends on the additional distance that the noise is forced to travel.

The key factors that dictate the performance of the barrier are its height and its distance from both the source and receiver. The optimum positions are those where the greatest shadow is cast – typically as close to the source as is practical as shown in the diagram.

Whilst geometry is the key factor that determines the attenuation, it must have sufficient mass to prevent noise travelling through, rather than over the barrier.

In general, the maximum barrier attenuation that can be achieved is around 20dB, but this is very much affected by the frequency of the sound. Barrier performance depends on the wavelength of the sound compared with the barrier height. Low frequencies have large wavelengths, so the barrier appears relatively smaller than for high frequency sound and therefore provides less attenuation.



For example, for a configuration that provides 15dB attenuation at 1kHz the barrier might be 3 wavelengths (0.34m) tall (c 1m). At 100Hz, the barrier would need to be c 10m tall (3.4m wavelength) for the same attenuation.

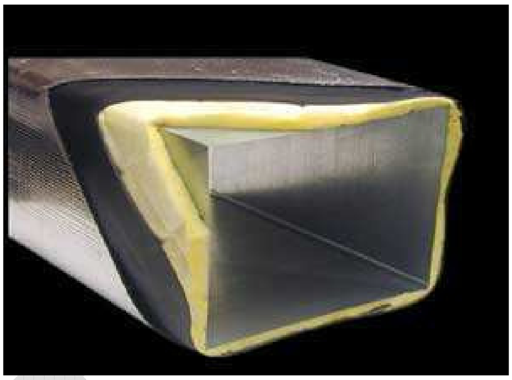
Barrier mass materials range from wood, steel and concrete (fixed barriers) to PVC or other flexible materials for temporary or mobile barriers.

In addition, barriers should be lined with acoustic absorbent to prevent reflections that amplify the sound. Mobile barriers usually have the acoustic absorbent built in.

The only way to evaluate the attenuation that a barrier will provide is to calculate barrier performances from the geometry and the sound frequencies involved (there's a useful online tool at https://echobarrier.co.uk/barrier-calculation-tool). However, it is recommended that a competent person completes the barrier design and specification using noise modelling software where deemed necessary.

13.8 Acoustic Lagging

Acoustic lagging is used to reduce noise breakout from ducts, pipes and plant casing e.g. fan volutes. It comprises a flexible layer such as rockwool, fibreglass or foam (usually open cell) covered with an outer mass layer. The latter can be constructed from materials such as flexible mass loaded PVC or metal sheet. The inner layer reduces the vibration transmitted into the mass layer to provide high attenuation and can also be acoustically absorbent.



Whilst this can be a very effective noise control measure, it can often trap moisture against the surface that can cause problematic corrosion and it can also make inspection difficult.

13.9 Controlling Reverberation

The noise from plant increases when it is confined within a building due to the reverberation caused by sound reflecting off the surfaces (steel, plasterboard etc). The noise within these confined spaces may then pass through the walls and is radiated out into the environment.

The reverberant noise and therefore the external noise level, can be reduced by installing acoustic absorbent inside on the walls or on the ceiling. In a small space such as an enclosure, the reduction could be as much as 10dB. In a larger space it might be around 5dB, depending on the area of absorbent used. However, acoustic absorbent lining is costly, so the minimum area and locations for the maximum cost/benefit should be calculated.

In summary, Noise control techniques are complex and require the specialist advice of a competent person. Detailed diagnostics of the noise sources is required prior to the design and implementation of noise control measures. Further information on environmental noise control can be found at https://invc.com/resources/technical-notes-environmental-noise/.

14.0 SPECIFIC ACTIVITIES

Three specific activities that may also be present on a site that requires an IE/IPC or Waste Licence are outlined in this section to highlight additional guidance documents or issues that need to be considered in the management of noise from these activities.

14.1 Quarrying and Mining Operations

Guidance relating to noise and vibration for quarrying and mining operations are provided in the Agency publication Environmental Management in the Extractive Industry (Non-Scheduled Minerals), (2006). Section 3.5 Noise *& Vibration* of this document sets out appropriate noise limit values and deals with control of noise, vibration and air overpressure.

14.2 Wind Turbines

The Agency *Guidance Note on Noise Assessment of Wind Turbine Operations at EPA Licensed Sites (NG3)* provides guidance on assessing the potential noise impact on NSLs from wind turbines on Agency licensed sites and a noise impact assessment methodology to ensure that all data generated is reliable and that resultant recommendations are fully justifiable. The Department of Housing, Planning and Local Government *Draft Revised Wind Energy Development Guidelines December 2019* provides guidance on Wind Turbine Noise also (most up to date version must be used in all cases). Note some EPA licensed sites have wind turbines so they may need to refer to both NG3 and NG4 for noise assessment purposes.

14.3 Waste Related Operations

Noise is produced during the acceptance, handling and processing of waste at landfills, waste transfer stations, MRFs and waste treatment facilities and during the removal of wastes off-site. Regarding the latter, it is considered that traffic movements associated with the waste facility on the public road network are an issue for the relevant local authority.

Typical sources of noise would include:

- Vehicle and plant movements on-site associated with the delivery of waste;
- Movement of plant around the site, including reversing alarms;
- Deposition, compaction, loading, sorting and covering of waste;
- The construction of new landfill cells and the capping and restoration of filled cells;
- Localised noise emissions on an intermittent basis e.g. vehicle and wheel cleaning, lifting operations, generators;
- Fixed plant such as landfill gas flares, leachate treatment equipment, shredders, trommels, compactors, picking lines and bailers; and
- Emission control equipment such as negative air pressure systems.

All licensed landfills and waste management facilities must be operated in accordance with the conditions of the waste licence from the Agency. The licence typically includes requirements for site specific noise measurements and generally sets out emission limit values for noise emissions from the facility.

An effective Noise Management Plan for a waste facility will typically require detailed consideration of a variety of noise control measures. Many of the general noise management techniques referred to in Section 11 and control techniques referred to in Section 13 are directly applicable to these types of sites, e.g.

- Fixed plant should be located as far away as possible from NSLs;
- Use buildings to contain noisy fixed plant and undertake noisy activities indoors, where practicable;
- Employ noise reducing technologies, such as source control/attenuators or enclosures, where practicable;
- Ensure that any noise control measures are maintained as per the manufacturers' requirements;
- Use screens around plant or equipment, and;
- Ensure that enclosures and doors/windows are properly sealed and/or closed.

In addition, traffic management can often be the cornerstone to good noise control. Appropriate traffic management measures include:

- Minimise the number of vehicles/heavy plant on-site at any one time;
- Maintain vehicles in good order, employ the principles of preventive maintenance and undertake reference vehicle noise measurements at defined intervals;
- Ensure that noisy vehicles are parked as far as possible from noise sensitive areas;
- Switch off idling engines where possible and prevent excessive revving;
- Maintain road surfaces in good order;
- Ensure that drivers are aware of the potential for noise to cause annoyance/disturbance to local residents – they should show due regard to this, particularly when entering and leaving the site (e.g. no unnecessary horn blowing), and;
- Consider the use of alternative varieties of reversing alarm with reduced noise output, such as ambient noise sensing alarms with variable volume or directional modulated alarms – these must be evaluated on a case-by-case basis and regard must be had to any health and safety issues that may arise.

Noise is liable to give rise to complaints whenever the level exceeds the pre-existing level by a certain margin or whenever it exceeds certain absolute levels. Given that these sites, particularly landfills, are often located in relatively remote areas likely to have low background noise levels, extra vigilance is required whenever noisy plant is operating close to the site boundaries and/or NSLs. In such circumstances it may be possible to secure some relaxation in the typical noise limits imposed by the facility's licence. However, at all times regard must be had to the potential off-site impact and appropriate controls must be adopted. Minimizing the early morning and late evening operational hours will be essential in many cases and the development of good communications with neighbouring residents is often helpful.

14.4 Construction Noise

BS 5228-1: 2009 + A1: 2014 *Code of practice for noise and vibration control on construction and open sites – Part 1: Noise,* provides guidance concerning methods of predicting and measuring noise and assessing its impact on those exposed to noise from construction and open sites. The calculation method may be of assistance in terms of licensed sites, and it could be used to predict noise at open sites, particularly landfill and quarry sites. Although other methods require the use of frequency analysis, BS 5228-1 allows for the use of A-weighted levels, which is likely to make it easier to apply in practice. However, care must be taken since it does not specifically take account of tonal elements in a noise source.

Appendix 1. Glossary of Acoustic Terms

Term	Description
A-weighting	The human ear is less sensitive at very low and very high frequencies, so it is not uniform across the sound spectrum i.e. we can't typically hear very low and very high frequencies. To account for this, a filter (A-Weighting) is applied to sound that represents the frequency response of human hearing.
Agglomeration	An Agglomeration is defined under the European Communities Environmental Noise Regulations 2018 (as amended) and includes: **Cork -** encompassing area regulated by Cork City Council and Cork County Council **Dublin** – encompassing areas regulated by Dublin City Council, Dun Laoghaire / Rathdown County Council, Fingal County Council, South Dublin County Council, Kildare County Council & Wicklow County Council. **Limerick** – encompassing areas regulated by Limerick City and County Council & Clare County Council.
Acoustic shadow	An acoustic shadow is an area through which sound waves fail to propagate, due to topographical obstructions or disruption of the waves via phenomena such as wind or air temperature gradients
Ambient noise	The totally encompassing sound in a given situation at a given time, usually composed of sound from many sources, near and far.
Attenuation	The reduction in level of a sound between the source and a receiver due to any combination of effects including distance, atmospheric absorption, acoustic screening, the presence of a building façade, etc.
Background noise	The steady existing noise level present without contribution from any intermittent sources. The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 per cent of a given time interval, T ($L_{AF90,T}$).
BAT	Best Available Technique (BAT) is the most effective technique available to a particular industry sector to achieve a high general level of protection of the environment. All EPA licensed Industrial Emissions sites are required to apply BAT

Term	Description
Broadband Noise	Sounds that contain energy distributed across a wide range of frequencies.
C-weighting	C Weighting is usually used for Peak measurements and also in some entertainment noise measurement, where the transmission of bass noise can be a problem. It is similar to the A-weighting, other than there is little attenuation at low frequencies.
Competent person	Individual possessing a combination of sufficient qualifications, training, experience and knowledge appropriate to the nature of the work to be undertaken, as outlined in Section 4 and who can demonstrate both practical and theoretical competence.
dB	Abbreviation for 'decibel' which is the scale in which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the **RMS** pressure of the sound field and the reference pressure of 20 micropascals (20 μPa).
END	Environmental Noise Directive (2002/49/EC).
Facade level	A facade sound level is typically measured 1 metre in front of the most exposed window or door in a facade. As sound is reflected from hard surfaces in a similar manner to light by a mirror, this effect increases the noise level compared with that measured without the building present by ~3 dB. For façade noise levels measured at dwellings, subtract 3dB to correct for the reflected sound.
Fast time-weighting	Fast response has a time constant of 125 milliseconds on a sound level meter.
FFT	Fast Fourier Transform (FFT) is a method to determine the detailed frequency content (narrow band analysis) of noise in a manner similar to that of the human ear.

Term	Description
Free Field	These are conditions in which the radiation from sound sources is unaffected by the presence of any reflecting boundaries or the source itself. In practice, it is a field in which the effects of the boundaries are negligible over the frequency range of interest. In environmental noise, true free-field measurement conditions are seldom achieved and generally the microphone will be positioned at a height between 1.2 and 1.5 metres above ground level. To minimise the influence of reflections, measurements are generally made at least 3.5 metres from any reflecting surface other than the ground.
Frequency	The number of acoustic pressure fluctuations per second occurring about the atmospheric mean pressure (related to the 'pitch' of a sound), measured in Hertz (Hz).
Frequency analysis	The analysis of a sound into its frequency components
Hertz (Hz)	The unit of sound frequency in cycles per second of acoustic pressure fluctuations about the atmospheric mean
Important Area - IA	These are required under the European Communities (Environmental Noise) Regulations 2018 (S.I. 549/2018) as amended by S.I. 663/2021. Important Areas are defined in the Local Authority Noise Action Plan and are generally defined as those areas where the noise level exceeds a L_{den} of 53dBA and/or the L_{night} of 45dBA. See also Most Important Area and Priority Important Area.
Impulsive	A noise that is of short duration (typically less than one second), the sound pressure level of which is significantly higher than the background. Impulsive noise has regard to the rapidity of the change in sound level and the overall change in sound level.
Intermittent	A noise level that increases and decreases rapidly at regular or irregular time intervals, where the duration of each such occurrence is more than about 5s is intermittent noise e.g. cars passing on a road, train noise, aircraft noise, and air-compressor noise.
Linear	The unweighted (linear) sound i.e. with no weightings applied (to account for how humans hear sound). Sound is measured in linear scale to identify tones, denoted dB(Z) or dB(L)

Term	Description
$L_{Aeq,T}$	The steady sound level which has the same energy as a time varying sound signal, when averaged over the same time interval, T. This parameter is not related to the statistical noise parameters (L_{AF10} or L_{AF90}) although for steady noise, all three will approach the same value.
$L_{Ar,T}$	The Rated Noise Level, equal to the site specific L_{Aeq} during a specified time interval (T), plus specified adjustments for tonal character and/or impulsiveness of the sound.
L_{Aeq_dt}	This is the Sound Level - "delta t" Level - within the logging interval. e.g. If the logging interval is 1 second, then L_{Aeq_dt} is the time averaged level of each second.
L_{AF}	A-weighted sound pressure level with FAST time constant as specified in IEC 61672-1
L_{AFN}	The A-weighted noise level exceeded for N% of the sampling internal. Measured using the "Fast" time weighting.
L_{AF10}	Refers to the A-weighted noise levels in the top 10 percentile of the sampling interval; it is the level which is exceeded for 10% of the measurement period. It is used to determine the intermittent high noise level features of locally generated noise and, for example, gives an indicator of the level of road traffic or other intermittent noise. Measured using the "Fast" time weighting.
L_{AF90}	Refers to the A-weighted noise levels in the lower 90 percentile of the sampling interval; it is the level which is exceeded for 90% of the measurement period. It will therefore exclude intermittent sources and is used to describe a background level. Measured using the "Fast" time weighting.
L_{AFmax}	The maximum **RMS** A-weighted sound pressure level occurring within a specified time period. Measured using the "Fast" time weighting.
L_{AFmin}	The minimum **RMS** A-weighted sound pressure level occurring within a specified time period. Measured using the "Fast" time weighting.

Term	Description
L_{den}	**L_{den}** is the day-evening-night noise indicator which is generally used for traffic noise assessments and it represents the noise indicator for overall annoyance. As traffic noise varies from moment to moment, a single figure indicator L_{den} is used, termed L_{day}, $L_{evening}$ and L_{night}. It is the energy average sound pressure level (L_{Aeq}) over a 24-hour period, with a penalty of 5 dB added for the evening hours between 19:00 to 23:00, and a penalty of 10 dB added for the nighttime hours between 23:00 to 07:00.
L_{night}	**L_{night}** is the noise indicator for sleep disturbance L_{Aeq},8hr (23:00 to 07:00).
L_{pA} (dB)	An 'A-weighted decibel' - a measure of the overall level of sound across the audible frequency range (20Hz – 20kHz) with A-frequency to compensate for the varying sensitivity of the human ear to sound at different frequencies.
Lw	See Sound Power Level
Low background noise	In the context of this guidance, an area of low background noise is one where the existing background noise levels measured during an environmental noise survey are as follows: o Average Daytime Background Noise Level ≤40dB L_{AF90}, and; o Average Evening Background Noise Level ≤35dB L_{AF90}, and; o Average Night-time Background Noise Level ≤30dB L_{AF90}.
Low frequency noise (LFN)	For the purposes of this document, noise which is dominated by frequency components towards the lower end of the frequency spectrum, typically at frequencies below around 200Hz is low frequency. Standards vary in their definition of the low frequency noise range e.g. ISO1996-1 refers to low frequency sound as being within the one-third octave bands 16Hz to 200Hz and NANR45 refers to analysing low frequency sound within the range 10Hz and 160Hz.
LCpeak	Level of peak sound pressure with C-weighting, within a specified time interval
Most Important Area - MIA	These locations are a sub-set of Important Areas where the health effects are highest, typically through a product of noise exposure levels and the number of people exposed to noise. See also Important Area and Priority Important Area

Term	Description
NANR45	Proposed criteria for the assessment of low frequency noise disturbance (NANR45) was produced by Salford University (2005, Revised 2011) and a method for identification of low frequency noise
Narrow band Frequency Analysis	In the audio spectrum, narrowband analysis is the examination of sound that occupy a narrow range of frequencies and this helps identify the exact tonal frequency of a sound, if present.
Noise	Any sound, that has the potential to cause disturbance, discomfort or psychological stress to a person exposed to it, or any sound that could cause actual physiological harm to a person exposed to it, or physical damage to any structure exposed to it, is known as noise.
Noise Floor	The noise floor of a device or system is the amount of noise generated by the device itself with no signal present, it is measured in decibels. All electronic devices including sound level meters will generate a certain amount of noise.
Noise sensitive location	NSL – any dwelling house, hotel or hostel, health building, educational establishment, place of worship or entertainment, or any other facility or other area of high amenity which for its proper enjoyment requires the absence of noise at nuisance levels.
Octave band	A frequency interval, the upper limit of which is twice that of the lower limit. For example, the 1,000Hz octave band sums the acoustical energy between 707Hz and 1,414Hz. The centre frequencies used for the designation of octave bands are defined in ISO and ANS standards.
OEE	EPA Office of Environmental Enforcement, whose role is to enforce compliance with the licences, permits and authorisations issued by the EPA.
Onset	Impulsive sound is sound with a sudden onset i.e. a sound that that begins suddenly. Onset is used to identify impulses in a sound using A-weighted sound pressure level time profile with Fast time weighting. An onset is identified from the time profile when the onset rate exceeds $R_{on} = 10$ dB/s. The predicted prominence of the impulse depends also on level difference D_L, i.e. the strength of the impulse in decibels.

Term	Description
Priority Important Area - PIA	Priority Important Areas are those which will be addressed by the Local Authority during the implementation of the Noise Action Plan. See also Important Area and Most Important Area.
Rating level	See $L_{Ar,T}$. – this is the site-specific Noise Level (L_{Aeq}) during a specified time interval (T), plus specified adjustments for tonal character and/or impulsiveness of the sound. For a licensed site, the rating level must be compared to the noise limit value in the licence.
RMS	The RMS (Root Mean Square) value of a set of numbers is the square root of the average of their squares.
Scheduled Activity	An activity falling under the First Schedule to EPA Act 1992 & 2003 as amended and the Third and Fourth Schedule of the Waste Management Act 1996 as amended, which requires an Industrial Emissions (IE) Licence, Integrated Pollution Control (IPC) Licence or Waste Licence.
Sound power level	Referred to as Lw or SWL, this is the logarithmic measure of sound power in comparison to a referenced sound intensity level of one picowatt (1pW) per m² where: $$Lw = 10 Log \frac{W}{W_0} \text{ dB}$$ Where: W is the rms value of sound power in pascals; and W0 is 1 pW.
Sound pressure level	Sound pressure refers to the fluctuations in air pressure caused by the passage of a sound wave. It may be expressed in terms of sound pressure level at a point, which is defined as: $$Lp = 20 Log \frac{P}{P_0} \text{ dB}$$ Where: P is the sound pressure; Po is a reference pressure for propagation of sound in air and has a value of 2x10-5Pa.

Term	Description
Soundscape	A soundscape is a sound or combination of sounds that forms or arises from an immersive environment. The study of soundscape is the subject of acoustic ecology. The idea of soundscape refers to both the natural acoustic environment, consisting of natural sounds, including animal vocalizations and, for instance, the sounds of weather and other natural elements, and environmental sounds created by humans, such as ordinary human activities including conversation or work, and also sounds of mechanical origin resulting from use of industrial technology. The disruption of these acoustic environments results in noise pollution.
Specific Noise Level	A component of the ambient noise which can be specifically identified by acoustical means and may be associated with a specific source. BS 4142, definition states that it is the 'equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, Tr.
Spectrogram	A spectrogram is a visual/coloured representation of the spectrum of frequencies of a signal as it varies with time. A spectrogram can show a sudden onset of a sound. Often it can be easier to see clicks and other glitches in this view rather than in a time or spectrum analysis.
Strategic Noise Map	A graphical representation of the predicted noise in a particular area and from particular noise sources, with different colours representing different noise levels in decibels [dB(A)]. Strategic Noise Maps are required under the Environmental Noise Directive and are produced every 5 years for major roads, rail and airports and reported by each Local Authority in their Noise Action Plan.
Slow time-weighting	Slow response has a time constant of 1000 milliseconds or 1s on a sound level meter
SWL	See Sound Power Level - W for Watts, also known as L_w
Time Weighting	One of the averaging times (Fast, Slow or Impulse) used for the measurement of RMS sound pressure level in sound level meters.

Term	Description
Tone	Sound characterised by a single-frequency component or narrow-band components where the concentration of acoustic energy is in a very narrow frequency range and this results in a clearly audible tone i.e. a distinguishable, discrete or continuous noise (hum, whine), which is referred to as being 'tonal'.
Threshold of Hearing	The lowest amplitude sound capable of evoking the sensation of hearing in the average healthy human ear (0.00002 Pa, equivalent to 0 dB).
1/3 Octave Analysis	1/3 Octave analysis is the standard method used to identify prominent tones. It provides a slightly higher frequency resolution than first octave band (1/1 octave) analysis as it splits each octave band into three. For example, the 1kHz third-octave band sums the noise energy from 891Hz to 1122Hz. 1/3 octave analysis should be used with caution as it may not identify all tones; FFT or narrow band analysis should be used in these circumstances.
Z Weighting	Z or ZERO frequency-weighting was introduced in the International Standard IEC61672 in 2003 and was intended to replace the "Flat" or "Linear" frequency weighting provided by manufacturers of noise meter.

Appendix 2. Quiet Area Screening

	Long-term Noise Monitoring Equipment set up	Tick
Noise Meter Requirements	Noise meter calibration date (within 2 years of monitoring)	
	Noise calibrator calibration date (within 1 year of monitoring)	
	On-site calibration level before measurement	
	On-site calibration level after measurement	
	Noise monitoring location, National Grid Reference (6 digit E,N)	
	Set meter to record L_{Aeq}, L_{AF90}, L_{AF10}, L_{AFmax}, L_{AFmin} over 15min interval. (If a different interval is used, justify its use in report)	
Met Logger Requirements	Set met data logger set to record: • Wind speed (m/s) • Wind direction (degrees) • Rainfall (mm) for the same period as the noise meter	
	Met logger calibration date	
• Start noise meter and met data logging to the nearest 15min period		
• Record person who sets up and takes down equipment		
• Note any issues when checking or taking down the noise meter e.g. power off, movement of microphone, evidence of tampering etc.		

Quiet Area Screening – Data Analysis:

1. Combine noise data with meteorological data.
2. Remove data corresponding to periods of rainfall.
3. Remove data corresponding to periods where wind speeds exceed 5m/s.
4. Segregate data into daytime (07:00 to 19:00hrs), evening time (19:00 to 23:00hrs) and night-time (23:00 to 07:00hrs).
5. Correlate noise data with wind data standardised to 10 metre height and calculate best fit polynomial (2nd or 3rd order) regression line through data. If there is no

relation between noise and wind speed straightforward averaging may be used. Append analysis to this document.

6. Determine the arithmetic average background noise level (L_{AF90}) for each time period at each wind speed integer values (1m/s, 2m/s) from the correlated noise data produced in Step 5, as shown:

Quiet Area Screening Data Processing	dBA at Wind Speed (m/s				
	<1	1-2	2-3	2-4	4-5
Average Daytime Level, dBA L_{AF90}					
Average Evening Level, dBA L_{AF90}					
Average Night-time Level, dBA L_{AF90}					

7. Reproduce analysis for each receiver location.
8. Save file as read-only to prevent tampering.

The overall aim in Quiet Area Screening is to try to ensure that new activity or development does not increase existing background noise. So for a background L_{A90} of 40dBA, for example, the target noise for a new development (L_{ArT}) would be 30dBA.

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. This may apply if the measured background sound levels are less than 10dB above the noise floor of the measuring system.

Appendix 3. Baseline Attended Noise Survey Set up Example

Baseline Attended Noise Survey Monitoring Record Required	Details	
Site Name		
Licence Application Reference Number		
Date of Survey and start time		
Surveyor		
Noise meter calibration date		
Calibrator calibration date		
On-site calibration level before measurement		
On-site calibration level after measurement		
Noise monitoring location, National Grid Reference (6 digit E,N)		
Set noise meter to record L_{Aeq}, L_{AF90}, L_{AF10} L_{AFmax}, over 15min interval (If a different interval is used, justify its use in report)		
Equipment used for weather monitoring		
	Start of survey	End of survey
Average Wind speed m/s		
Wind direction (degrees)		
Temperature ^{0}C		
Rain (yes/no)		
Note other weather details (wet ground, sunny, cloudy, cold, frosty, fog etc)		
Note sources of noise on-site		
Note sources of noise off site		
Any other relevant information		

Baseline Attended Noise Survey Monitoring Data Processing:

- Segregate data into daytime (07:00-19:00), evening time (19:00-23:00) and night time (23:00-07:00) as per the table in this Appendix;
- Determine the average background noise level (L_{AF90}) for each time period using the results for each sample measurement;
- Reproduce analysis for each receiver location.

Low Background Noise Screening Data - Example Template for Calculation Purposes

Receiver:	Location 1 – 200m SW from proposed boundary line					
Period	Time	Measured Noise Levels (dB re. $2x10^{-5}$ Pa)				Comments
		L_{Aeq}	L_{AFmax}	L_{AF10}	L_{AF90}	
Daytime	10:43-10:49	43	63	45	38	Ambient noise levels dictated by occasional steam release. Max level associated with traffic movement. Background noise dictated by broadband emissions from ACME plant
	11:52-12:07	43	65	44	38	
	12:50-13:05	44	68	46	39	
	14:10-14:25	43	65	44	38	
	Arithmetic Average of L_{AF90} (dB)				38	
	Low Background Noise Daytime Criterion, dB $L_{Ar,T}$				≤45	
Evening	19:34-19:49	38	63	40	31	ACME plant not operating. Max levels associated with traffic movement. Background noise dictated by distant road traffic and a low level of wind noise in foliage.
	20:52-21:07	36	55	35	29	
	21:05-22:05	36	61	38	31	
	Arithmetic Average of L_{AF90} (dB)				30	
	Low Background Noise Evening Criterion, dB $L_{Ar,T}$				≤40	
Night-time	23:05-23:20	34	46	33	26	Max level associated with car parking at nearby residence. Background noise dictated by distant road traffic and a low degree of wind generated noise.
	00:15-00:30	35	47	32	25	
	01:15-01:30	33	43	30	23	
	Arithmetic Average of L_{AF90} (dB)				25	
	Low Background Noise Night-time Criterion, dB $L_{Ar,T}$				≤35	
Reported by:	Name:					
	Position:					
	Date:					

The above site is deemed to be in an area of low background noise as all three (day, evening and night-time) criteria are met, so the low background noise limits (45dBA, 40dBA and 35dBA) would apply to this location.

The above table is indicative only to demonstrate the calculation of the noise levels to compare with the low background noise limits. A baseline survey for a proposed facility would require a much longer survey that indicated here, as discussed in Section 5.5, to be determined by the competent person on a case-by-case basis.

The baseline survey must be representative of the variation in noise levels occurring between day evening and night time intervals over the period of multiple days or weeks where necessary (especially for rural locations). In all cases, the duration of the survey must be justified in the report.

Appendix 4. Tonal Noise Identification using Smartphone App

Details provided in this Appendix may be used as an additional tool to assist the licensee/ surveyor determine if tonal noise is present in the field and at what frequency, using a smartphone app, to aid subjective determination of tones. This method cannot be used for assessing compliance with licence conditions and it is not a validated standard method; all noise measurements presented in noise reports for licensing purposes must be validated with a calibrated SLM and specialised software.

The ability to determine if tones are present subjectively is a skill that is often very unreliable, particularly when there are multiple tones, where the tonal element is not dominant or where you cannot listen at the location of the complainant (ideally inside the house if that is where complaints could be made).

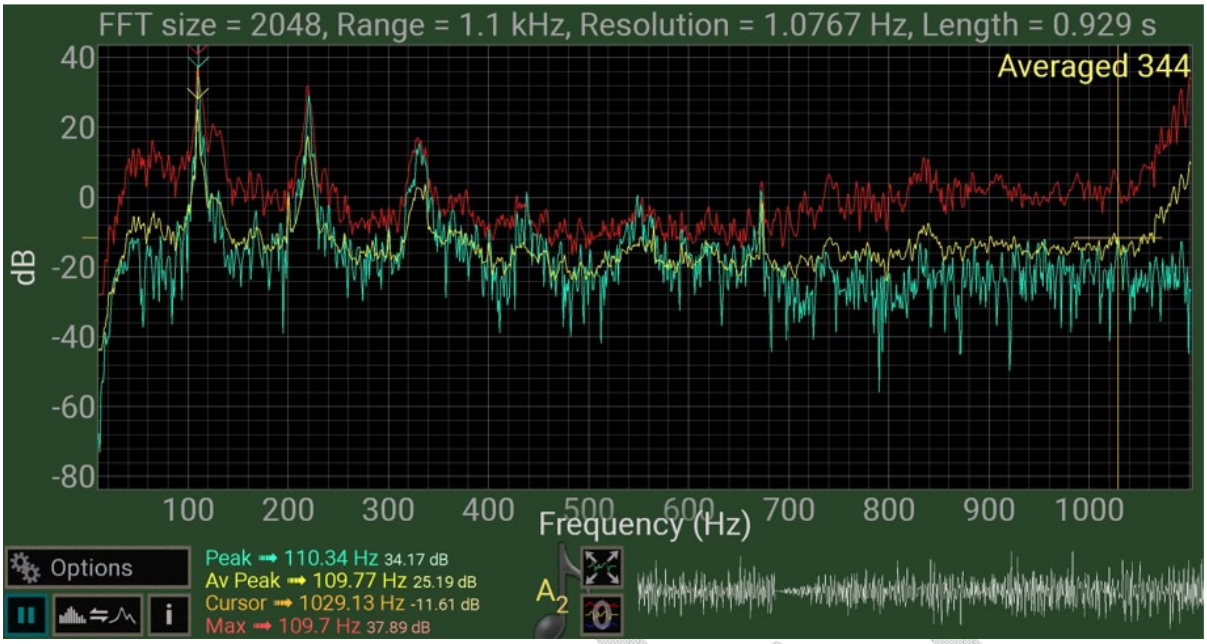
As a matter of course (or if there are any doubts), the surveyor can use one of the many free (or very low cost) FFT spectrum analysis smartphone apps to provide an objective evaluation of the presence of tones. Smartphone noise apps are not a calibrated source for measuring broadband noise to compare with limit values and they can never be used for this purpose. However, they are an additional tool to aid the subjective determination of the presence of tonal noise and the frequency i.e. they allow you to see what you are hearing in the field.

Whilst the smartphone noise spectrum signature amplitude will vary with frequency depending on the frequency response of the microphone and electronics, the measured tonal frequency and the relative amplitude between the tone and the broadband noise either side of the tone are accurate to within Class 1 sound level meter standards.

Once a smartphone app is used correctly and its limitations are known, then it may be used for investigative purposes to aid the subjective determination of tonal noise. Smartphone microphones do not have a flat frequency response. They tend to roll-off at low frequencies to reduce the effects of wind noise. However, in most cases this only becomes a significant effect below around 100Hz (although it may start to roll off below around 200Hz). This means that the absolute amplitude of low-frequency components will often gradually reduce below 100Hz - 200Hz, but that the ratio between the broadband noise and a tone at a particular frequency will not change until the level is low enough to be influenced by the noise floor of the phone microphone.

The following screenshot from the Keuwl Spectrum Analyser App clearly indicates tones and harmonics at a monitoring location:

Example of Smartphone FFT Spectrum Analysis App



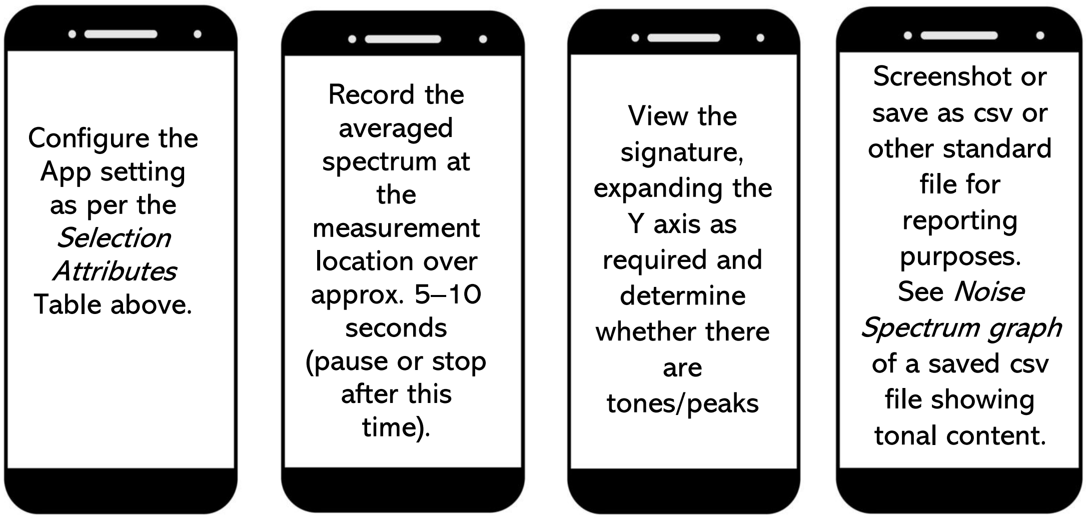
Note there are many smartphone apps that may be used for narrowband frequency analysis and the Agency does not recommend any specific one. In addition, new apps will be continuously developed. Instead, the key features required for the use of smartphone noise apps for narrowband frequency analysis is provided and these features should govern the selection of an effective app.

Smartphone App Selection Attributes

Options	Settings	Notes
FFT Size (Resolution)	1Hz – 2Hz	Ideally c 1Hz
FFT Range	0Hz – c 1kHz	Don't have to set to full 20kHz range as most environmental tones are below 1kHz
FFT Window	Hanning or Hamming	
Weighting	Linear, none or Z	
X Axis	Linear	To aid identification of harmonics
Y Axis	Decibels	
Averaging	On	Allow to display over a few seconds
Cursor	On	To pick up the tonal frequencies

The procedure for using a smartphone app in the field for the measurement of narrowband frequency analysis is shown in the following diagram:

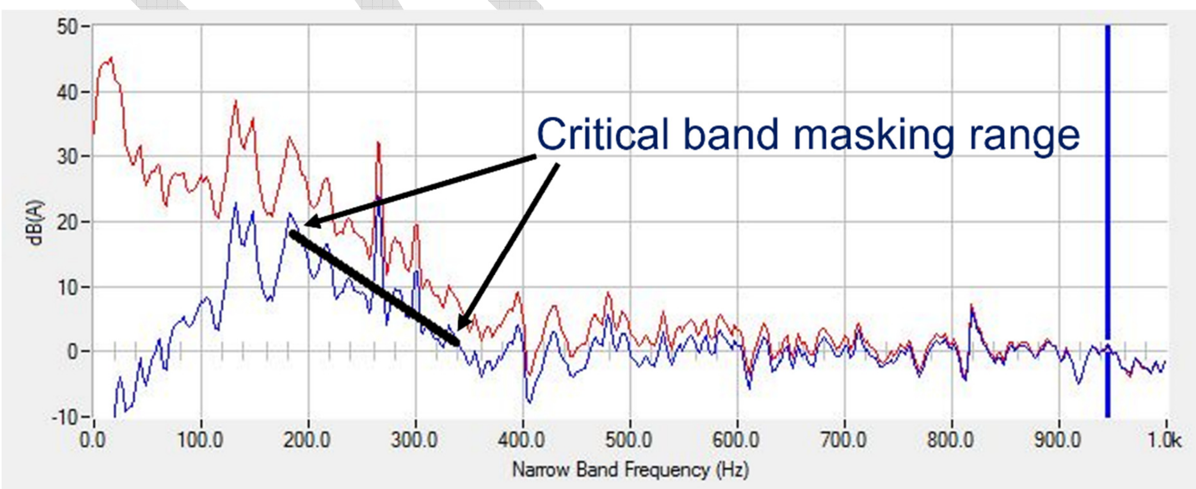
Smartphone App Measurement Procedure



Once a measurement is obtained in the using the recommended settings in Table 4, the data needs to be analysed to identify the tone and it's severity.

The noise spectrum graph provided shows (csv) data taken from a fan on an industrial site, which is downloaded from a smartphone reading. The smartphone reading is graphed in linear scale (red line) and also converted to A weighted scale (blue line) using acoustic software.

Noise Spectrum from Smartphone App Data



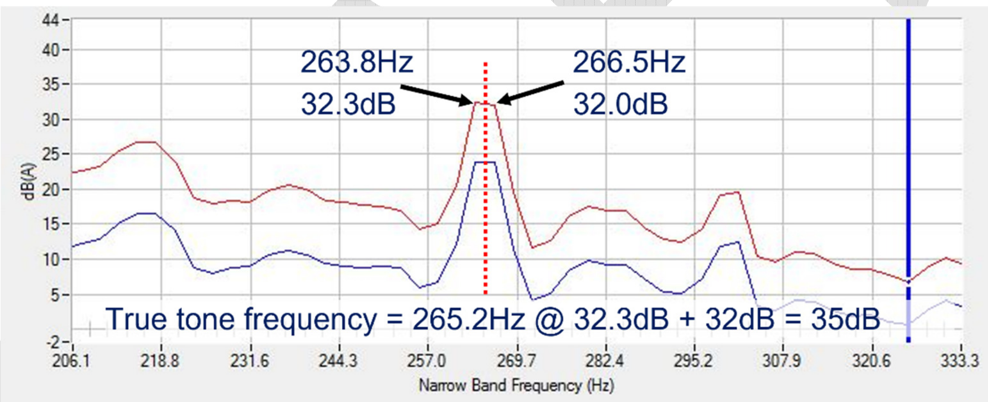
The graph shows a tone (peak) versus the broadband noise at the monitoring location.

To determine the amplitude of the tone over the broadband noise around the same frequency, this can be done by eye by marking the critical band and comparing the difference in level between the two.

Depending on the software used, you should also be able to zoom-in on the noise spectrum peak of concern, as shown in the following graph. This graph has a frequency resolution of 2.7Hz and shows that the tone is composed of two elements (263.8Hz and 266.5Hz), so adding the amplitudes and interpolating the frequency gives the true values for this feature as a tone at 265.2Hz with an amplitude of approximately 32dB that is around 15dB or so above the broadband noise around the same frequency, a slightly higher value than the one you get from viewing the un-zoomed signature.

For this example, a significant adverse impact is expected if noise sensitive locations are close to this area, and complaints would very much be expected. A tonal penalty may be assigned by FFT analysis in this instance, which is likely to assign a maximum penalty of 6dB.

Tonal Noise Assessment from Smartphone App Data



Evaluation of narrowband frequency analysis data includes the following;

1. A frequency plot similar to the noise spectrum one above, with a typical frequency resolution of 1Hz to 2kHz.
2. The x axis should be arranged to include only the minimum frequency range that illustrates the problem tones (in this example 0-1kHz). Note it is rarely necessary to go beyond 2kHz for environmental noise analysis.
3. A linear X axis is preferred to a log axis as this allows you to see the harmonics of tones (equally spaced along the axis). Set the Y axis to display all the relevant tonal amplitudes.
4. Where appropriate, overlay the noise sensitive location signature with the signatures take close to the suspect noise sources.
5. Look at the key frequencies and where possible link them to a specific noise source.

Appendix 5. BS4142 Assessment Example

A BS4142 Assessment Report is to include all items specified in Section 12 of the BS4142 standard, including context e.g light industrial, rural etc. An example of a BS4142 Assessment at two locations (A & B) is provided here and numerous examples are also provided in the standard as a guide.

Results		Location		Relevant clause	Commentary
		A	B		
Measured ambient sound level	L_{Aeq} dB(A)	46	53	7.1 7.3.1 7.3.9	Measured at night only. Specific noise under investigation present.
Residual sound level	L_{Aeq} dB(A)	43	43	7.3.2	During the assessment it was not possible to have a full site shutdown. Residual and background noise levels were recorded at a proxy location.
Night-time reference time interval	Mins	15	15	7.2	
Total “on time” during reference interval	Mins	30	30		Noise from site is continuous.
“On time” correction	dB	0	0	7.3.14	
Specific sound level	L_{Aeq} dB(A)	43	52.5	7.3.14	Ambient sound – Residual sound
Acoustic feature correction	dB	6	6	9.2	Tonal correction.
Rating level	dB(A)	49	58.5	9.2	Specific level + acoustic feature correction.
Background sound level	L_{A90} dB(A)	41	41	8.1 8.1.3 8.1.4 8.3	During the assessment it was not possible to have a full site shutdown. Background noise levels were recorded at a proxy location
Excess of rating over background sound level	dB	8	17.5	11	Rating level – background level.
The assessment indicates that a significant adverse impact is likely within the local area depending on the context				11	The rating level exceeds the background sound levels by 8 dB at location A and >10 dB at location B.
Uncertainty of assessment				10.2	The assessment has been based on a proxy background location, this introduces a degree of uncertainty.

Results		Location		Relevant clause	Commentary
		A	B		
					In addition, at Location A, the level difference between the ambient and residual is ~3dB. BS4142 states, that when the difference is 3 dB or less, a simple logarithmic subtraction to determine the specific source may underestimate the sound level radiated by the source. A prediction using ISO9613 may be appropriate in this instance. Despite the uncertainty, the level difference and tonal content witnessed at the assessment locations, suggests that the result is reflective of the current noise environment.

Note: ISO 9613 should be used where direct measurements cannot be taken.

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