

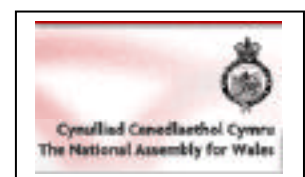
Report

Low Frequency Noise

**Technical Research Support
for
DEFRA Noise Programme**

This contract is managed by DEFRA on behalf of

DEFRA
Department of the Environment, Northern Ireland
Scottish Executive
National Assembly for Wales



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Casella Stanger

Low Frequency Noise Update

1 Introduction

- 1.1 This document has been produced by Casella Stanger under contract to DEFRA with the objective of providing
- an update of the current information available concerning low frequency noise; and
 - help for those involved in low frequency noise issues.

It has been designed only to provide some general information on the subject. It should not be regarded as formal guidance from DEFRA.

- 1.2 Possible causes and possible effects of low frequency noise are described, and a procedure for investigating complaints concerning low frequency noise is set out. Some general advice is given regarding the measurement of low frequency noise, but a detailed measurement procedure is not given. A further detailed report on the subject of the measurement of low frequency noise may be produced in due course.
- 1.3 In the field of low frequency noise and its perception, there are still a number of factors that make it difficult to derive specific, quantitative guidelines by which to judge the acceptability or otherwise of a given level of noise at low frequency. This document, therefore, tries to offer suggestions which may be helpful in explaining some of the factors most commonly affecting the outcome of investigations.

2 Background

- 2.1 Low frequency noise is not clearly defined but is generally taken to mean noise below a frequency of about 100 to 150 Hz. Noise at frequencies below about 20 Hz is sometimes referred to as infrasound and this type of noise presents even greater difficulties in its measurement and assessment. At these particularly low frequencies complainants often have difficulty in describing the source of their complaint, sometimes referring to “feeling the noise” or to “pressure sensations”.
- 2.2 The Report of the Noise Review Working Party 1990 published by the Department of the Environment (the Batho report) commented on low frequency noise. It said

“Low frequency noise does not give rise to the same level of concern as neighbourhood noise but it can have a serious effect on the quality of life of those affected by it. On average just over 500 cases of low frequency noise disturbance are reported each year compared to 67,000 cases of neighbourhood noise. It is often difficult to check on low frequency noise complaints because the sensitivity of individuals to such noise varies greatly. The noise may be inaudible to the EHO (Environmental Health Officer) and its measurement often requires sophisticated monitoring

techniques. In some cases the noise complained of may have no external source but be a result of a medical condition.

The Working Party was told that low frequency noise problems could occur anywhere in the range 10 –150 Hz but were usually associated with noise in the 40 – 60 Hz range. The commonest cause of such noise is industry but there can be many other causes, some of them domestic (refrigerators, oil-fired boilers, and washing machines) and some associated with road vehicles. Sometimes low frequency noise seems more like vibration than noise and it can cause structural vibration. It has also been postulated that non-acoustic sources such as high intensity electromagnetic fields or radar microwaves may create for some people the illusion of low frequency noise.

It will be apparent that low frequency noise presents particular problems for those who have to deal with complaints about it. It is in any case likely that the business of identifying the source of low frequency noise will be laborious and may not always be conclusive.

We accept that this problem, though it generates comparatively few complaints, is a real one. Much remains to be done to extend understanding of the nature of low frequency noise and how best to detect and deal with it.”

- 2.3 Much of the above continues to apply today, although statistics relating specifically to low frequency noise are still not gathered on a routine basis.
- 2.4 There are several factors relevant to low frequency noise propagation and its perception which need to be borne in mind:
- Mid and high frequency noise is attenuated by propagation through the atmosphere and also by attenuation due to its passage over acoustically soft ground such as grass land. Low frequency noise does not benefit to the same extent from either of these effects. This means that as a sound travels, its frequency content alters making the low frequencies more prominent at greater distances.
 - For people inside buildings with windows closed, this effect is exacerbated by the sound insulation properties of the building envelope. Again mid and high frequencies are attenuated to a much greater extent than low frequencies. Thus the frequency content again alters emphasising still further the low frequency content.
 - Resonance can be set up inside a room with nodes (quiet points) and anti-nodes (loud points). The number and position of these nodes and anti-nodes will depend on the specific room dimensions and the frequency of the noise. The consequence is that the room resonances can cause elevated levels of low frequency noise at points within a room.
 - People’s hearing tends to deteriorate with age, but not equally across the frequency spectrum. Hearing deteriorates more rapidly at the mid and higher frequencies than at the lower frequencies which means that

older people's hearing tends to be proportionately more acute at low frequencies.

- It has been postulated that some people exhibit discrete peaks in their hearing threshold. This means that a sound could appear tonal to one person but not to another.

2.5 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 by about 25 dB at 100 Hz, 40 dB at 50 Hz and 70 dB at 20 Hz (an attenuation of 70 dB is less than 1/100th as loud), compared with the level at 1000 Hz. At higher levels, the effect is not so marked with the attenuation being about 5 dB at 100 Hz, 10 dB at 50 Hz and just under 25 dB at 20 Hz (i.e. less than 1/5th as loud). This means that frequencies in the region of 20 Hz may not be audible unless the level exceeds about 70 dB. The A-weighting network found on most sound level meters is intended to reflect this response.

2.6 There are no British Standards that specifically refer to the assessment of Low Frequency Noise. There is an international standard,

“ISO 7196:1995(E) Acoustics – Frequency-weighting characteristic for infrasound measurements”,

which defines a G-weighting network specifically intended for the measurement of noise in the 1 to 20 Hz frequency range. Whilst this standard is used in some countries it is not in common use in the UK.

2.7 There is also a German Standard:

DIN 45680 : 1997 (Messung und Bewertung tieffrequenter Geräuschmissionen in der Nachbarschaft)

which provides guidance on the measurement and assessment of low frequency noise. It suggests that measurements should be made at the position identified by the complainant as the worst location in the room. It goes on to note that the measurement time interval will depend on the fluctuation of the noise but that the measurement should include at least one or more representative cycle. As a preliminary investigation it recommends that if the difference between the A-weighted and C-weighted L_{eq} values is greater than 20 dB then a low frequency noise problem should be suspected (the Batho report, see Para 2.2 above, made a similar observation but with a difference of 30 dB). It also provides useful guidance on assessing whether tones are present by comparing adjacent 1/3 octave bands. If noise in one band is more than 5 dB above the level in the immediately adjacent bands then the noise is judged to be tonal.

3 Possible Sources

3.1 Possible sources of low frequency noise are many and varied but are often industry related. The following is a list of common sources:

Pumps	Fans
Boilers	Ventilation plant
Heavy industry	Blasting
Electrical installations	Road, rail, sea and air traffic
Amplified music	Cooling towers
Wind farms	

- 3.2 It can be seen that the sources are generally industrial/commercial noise sources and are mostly located externally. However, low frequency noise can also be generated from internal domestic sources such as refrigerators. In addition to man-made sources there are some natural sources of low frequency sound such as the wind, the sea, thunder and vibration from low level ground movements.

4 Possible Effects

- 4.1 As with any noise, reported effects include annoyance, stress, irritation, unease, fatigue, headache, possible nausea and disturbed sleep.
- 4.2 As people's hearing sensitivity varies from one individual to another it is often the case that a low frequency noise can be heard by one person and not by another. Consequently it may annoy one person but not the other. This feature can sometimes mean that the person who is annoyed can also feel isolated.
- 4.3 Low frequency noise is sometimes confused with vibration. This is mainly due to the fact that certain parts of the human body can resonate at various low frequencies. For example the chest wall can resonate at frequencies of about 50 to 100 Hz and the head at 20 to 30 Hz.
- 4.4 In addition low frequency noise can cause lightweight elements of a building structure to vibrate causing a secondary source of noise. This vibration is generally superficial and should not be confused with vibration of the whole building.

5 Measurement and Assessment

- 5.1 There are a number of factors that make measuring and assessing low frequency noise difficult, especially at frequencies below 20 Hz. Among these are the following.
- Individuals appear to vary considerably in the sensitivity of their hearing at low frequencies.
 - It may be difficult to measure with conventional sound measuring equipment. Not all local authorities, who are generally the first to be asked to investigate, will have ready access to suitable equipment.
 - Even when identified, the nature of low frequency noise is such that it is often very difficult to locate the source, which could be quite distant from the receiver.

- 5.2 As the A-weighting network attenuates low frequencies by a large amount, any measurements made of the noise should be with the instrumentation set to linear. For a preliminary analysis, measurements should be made in 1/3rd octave frequency bands. More detailed analysis would need the use of narrower frequency bands or even an FFT (Fast Fourier Transform) analyser. In any event, it is preferable to use real time analysis so that instantaneous variations in level and frequency can be observed as they happen. Care should be taken to be aware of the lower limiting frequency of the measuring instrumentation.
- 5.3 Simple techniques can be employed by the investigator as a preliminary screening exercise. This could include placing their ear to the wall to try to detect the noise in the structure. As indicated in the German standard (see Para 2.7) another method is to observe the difference between A-weighted and C-weighted noise measurements. A difference of 20 dB could indicate high levels of low frequency sound. These simple screening methods should not, however, be used as a substitute for a full investigation.
- 5.4 As mentioned previously (para 2.4), resonance can occur in a room, which can mean large variations in measured sound levels at different points within the room. It is advisable, therefore, to measure at the location regarded by the complainant as being where the noise is loudest. This is most likely to be at the head position when standing or seated or when in bed. A measurement position in a room corner (approximately 15cm from the corner) is likely to be at an antinode and hence detect all resonant peaks. This can be useful as a reference measurement, particularly if comparable measurements will have to be made on a later occasion.
- 5.5 When trying to locate a source of low frequency noise, look first for the source within the building itself. This may require electrical items within the building to be turned off, e.g. electric clocks, refrigerators, extract fans, etc., or even temporarily turning off the electrical supply to the home. If this does not identify the source, then consideration should be given to external sources or sources in adjacent buildings. It must be remembered that low frequency noise can travel large distances, consequently the source could be quite distant. Experience has shown that sources could be as varied as a fish tank in the next room to a faulty bearing in a factory some 300 metres away.
- 5.6 Information on the source can often be gleaned from the spectral content of the noise. As a general rule electrical sources will generate noise at the mains frequency of 50 Hz, but harmonics may also be present, i.e. at 100 Hz and other multiples. Due to the way transformers operate, their fundamental frequency is double the mains frequency at 100 Hz. For rotating sources, such as fans, specific frequencies are often generated which relate to the number of blades and the speed of rotation. This is known as the blade pass frequency. In very general terms the lower the frequency of the noise the larger the physical size of the source is likely to be.

6 Investigation procedure

- 6.1 The general investigating procedure, as with any noise investigation procedure, should be to listen for the noise, measure the noise, assess the noise, locate the source and where necessary take action to resolve the problem.
- 6.2 Following extensive research by the Building Research Establishment and Sound Research Laboratories on behalf of the Department of the Environment a suggested Low Frequency Noise Investigation Protocol was developed. The protocol was originally published in 1994 and the following is based on that procedure.

Visit the Sufferer

- 6.3 The investigator's first visit should be handled with particular care and the complainant must be shown respect. The situation should be approached with an open mind in order to avoid an entrenched reaction by the complainant.
- 6.4 Continue to keep an open mind during the investigation. Discuss the problem with the complainant and obtain a history and background to it. The history should include the following.
- When the noise was first heard.
 - Type of noise heard.
 - Duration and frequency of occurrence of the noise.
 - Complainant's belief about the source.
 - Effects of the noise on the complainant.
 - Whether other family members hear the noise.
 - Whether neighbours hear the noise.
 - Whether the complainant believes that he/she is particularly sensitive to other sources of noise.
- 6.5 Listen for the noise. Ensure that the complainant can clearly hear the noise at the time of the investigation. This may mean having to investigate the noise at different times e.g. during the day, evening or night. If the noise can be heard by the investigator then attempt to find the source. Use measurements (as described below) to assist in the source identification. If the investigator cannot hear the noise and yet the complainant can hear it, then measurements should be made. Bear in mind that if other members of the complainant's family or their neighbours have heard the noise then there is probably a noise to be detected.

Measurements

- 6.6 As mentioned above it is preferable to use a narrow band or FFT real time analyser. Look for characteristics that relate to the noise experienced by the complainant, i.e. increases, decreases, the loudest place in the dwelling, etc. Try to quantify the level and frequency that appear to correlate with what the complainant is hearing.

If Nothing is Found

- 6.7 If no noise is heard or no particular low frequency noise can be measured there are several options. If it is believed that the measurements were made when the noise was not considered by the complainant to be at its worst, then a second visit would be advisable. However, consideration should be given to the possibility that the complainant is referring to a previous source that has now been abated.
- 6.8 If after a second visit the investigator is convinced that there is no noise, either heard or measured, that relates to the complaint, and no other family members or neighbours have heard the noise, then the complainant should be referred to an audiological specialist. This, of course, must be done in a sensitive manner, as a common criticism of low frequency noise investigation is that the problem is blamed immediately on tinnitus or some other related problem. The complainant should be told that the investigator has not been able to hear or measure the noise that they have described and that the sufferer should be examined by an audiological specialist as their hearing system may be part of the problem.
- 6.9 In fact low frequency tinnitus is reported to be very rare and is very difficult to confirm, however, a hearing test can be valuable in such cases.
- 6.10 A Decision Flow Chart to assist in the investigation process, based on the above procedure, is appended.

7 Contact Organisations

- 7.1 There are various organisations that may be able to assist those affected by low frequency noise and, in particular, may be able to facilitate contact with others in similar situations. The addresses of two such organisations are provided below. If there are other organisations that exist to help, please contact DEFRA, Zone 4/G16, Ashdown House, 123 Victoria Street, London, SW1E 6DE or email noise@defra.gsi.gov.uk.

Low Frequency Noise Suffers Association
Laundry Cottage
Home Farm
Leicester Road
Thornhaugh
Peterborough
PE8 6NL

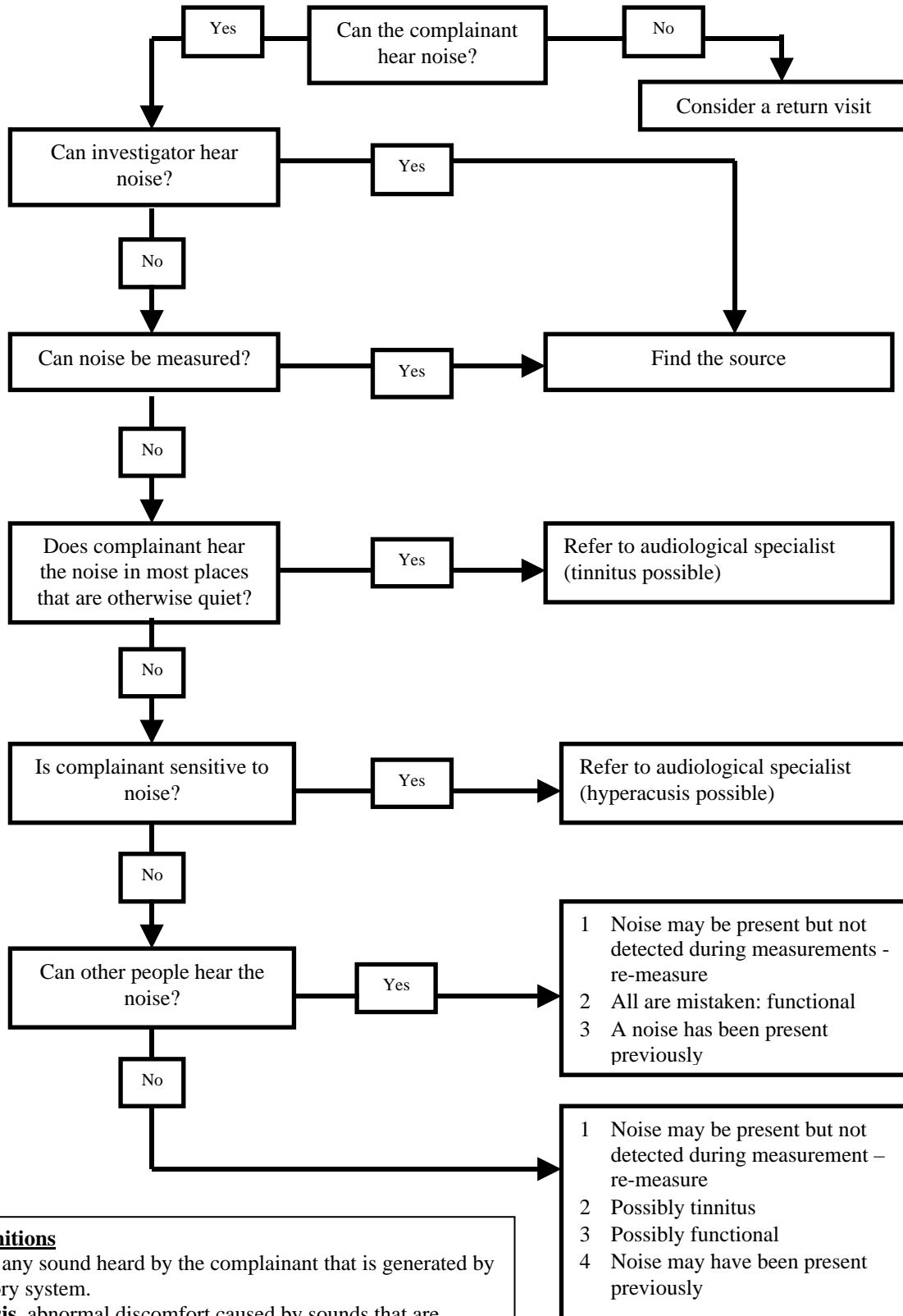
British Tinnitus Association
4th Floor White Building
Fitzalan Square
Sheffield
S1 2AZ

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Decision Flow Chart
To assist in Low Frequency Noise Investigation



Brief Definitions

Tinnitus – any sound heard by the complainant that is generated by their auditory system.

Hyperacusis abnormal discomfort caused by sounds that are usually tolerable to other listeners.

Functional A complainant has become convinced of the presence of the noise when it is not in fact present.