Residential development near industrial noise emitters

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ABSTRACT

The Noise Policy Statement for England (NPSE) utilizes two established concepts from toxicology. They are NOEL – No Observed Effect Level and LOAEL – Lowest Observed Adverse Effect Level. The NPSE extends these to the concept of a SOAEL – Significant Observed Adverse Effect Level, the level above which significant adverse effects occur. One aim of the NPSE concerns the situation between LOAEL and SOAEL. It requires that all reasonable steps be taken to mitigate and minimize adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This is consistent with consideration of Best Available Techniques (BAT) or appropriate measures under the EU's Industrial Emissions Directive (IED) and the UK's Environmental Permitting Regulations (EPR). Significantly, this would mean that any time noise levels could be above LOAEL values operators of regulated industry will need to demonstrate what noise mitigation has been considered, what mitigation has or will be adopted, a cost benefit demonstration as to why other measures are not being implemented and an explanation why emissions may be above acceptable levels on nearby land strategically designated for potential noise sensitive development. Where noise-related conditions have not been specifically written into a Permit, the Operator is still obliged to use BAT to implement and maintain appropriate preventative measures against noise related annoyance. This is often referred to as "residual BAT". This paper will discuss residual BAT and land use changes resulting in noise sensitive developments moving into the vicinity of EPR/IED authorized operations. This work is likely to be of interest to consultants, planners and policy makers involved in the control of environmental impacts of industrial activities.

INTRODUCTION

Legislative context

The key concerns regarding noise sensitive development near existing industrial land uses are:

- The occupiers of the new noise sensitive development may be subject to unacceptable noise.
- The existing industrial operation may be become subject to complaints from occupiers of the new noise sensitive development.

In the latter case, either common law or statutory nuisance, legal action be required to expend resources on implementing noise mitigation and management measures.

Control over the emission of noise from many industrial sites is exercised in the England by the Environment Agency via the Environmental Permitting regulations; whilst control over the emission of noise from an existing industrial site on any proposed nearby new noise sensitive is exercised by the local planning authority under the Town and Country planning regime.

Noise Policy Statement for England (NPSE)

An overarching policy statement for noise in England was published by the UK Government Department responsible for noise, Defra, in 2010, in its introduction this policy states:

"The Government is committed to sustainable development and Defra plays an important role in this by working to secure a healthy environment in which we and future generations can prosper. One aspect of meeting these objectives is the need to manage noise for which Defra has the overall responsibility in England."

The NPSE goes onto describe its long term vision as being to:

"Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development."

Aims of the NPSE

This long term vision is supported by the following aims: Through the effective management and control of environmental, neighbor and neighborhood noise within the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;
- mitigate and minimize adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life.

The NPSE goes onto to provide useful advice on interpretation of its aims, including at paragraph 2.18 where it states:

"There is a need to integrate consideration of the economic and social benefit of the activity or policy under examination with proper consideration of the adverse environmental effects, including the impact of noise on health and quality of life. This should avoid noise being treated in isolation in any particular situation, i.e. not focusing solely on the noise impact without taking into account other related factors."

The NPSE therefore strongly influences how the EPR/IED requirements are interpreted and applied.

ENVIRONMENTAL PERMITTING REGULATIONS (ENGLAND AND WALES) 2010

Best Available Techniques (BAT)

In England and Wales the Environmental Permitting Regulations (England and Wales) 2010 require installations to be operated in such a way that "*all the appropriate preventative measures are taken against pollution, in particular through the application of BAT*".

The definition of pollution includes *"emissions which may be harmful to human health or the quality of the environment, cause offence to any human senses or impair or interfere with amenities and other legitimate uses of the environment*". BAT is therefore likely to be similar, in practice, to the requirements of the long established Statutory Nuisance legislation, which requires the use of "best practicable means" to prevent or minimize noise nuisance.

Reasonable cause for annoyance

In the case of noise, *"offence to any human senses"* may be judged by the likelihood of annoyance during the day or sleep disturbance at night. However, a lack of complaints should not necessarily imply the absence of a noise problem and in some cases it may be possible, and desirable, to reduce noise emissions still further at reasonable cost and this may therefore be BAT for noise emissions in some circumstances. Consequently, one of the aims of BAT should be to ensure that noise does not cause reasonable cause for annoyance to persons beyond the installation boundary.

Balance of costs and benefits

BAT will be installation–specific and, in determining what constitutes BAT, a number of factors will need to be taken into consideration. The cost of applying a particular technique will need to be balanced against the increased benefit to the environment. Where an environment is particularly noise sensitive, the balance of costs and benefits will probably tip towards the need for additional cost, as the environmental advantages would justify the increased cost. In this case, the Operator may have to go beyond the standard that would constitute BAT in a less sensitive environment.

ASSESSMENT METHODS

BS 4142 – Method of rating industrial noise in mixed residential and industrial locations

In the case of noise, "*offence to any human senses*" may be judged by the likelihood of complaints, which is conventionally assessed in the UK using the methodology of BS 4142 (1997). BS 4142 has been in use in various versions since the 1960's. A report by the National Physics Laboratory concluded that BS 4142 worked well in 80 % of cases; but it was sometimes used inappropriately and this contributed to a significant proportion of the cases where it was not as effective.

However, in the context of residual BAT the use of BS 4142 has the specific drawback that it is an external based assessment of the likelihood of complaints from persons residing in a dwelling; and therefore normally cannot be altered by mitigation incorporated into the noise sensitive scheme; although such mitigation can provide adequate protection and acceptable noise conditions internally and externally to the scheme.

Consequently, by solely using the external based methodology of BS 4142 to assess the potential impact of existing industrial noise on proposed new noise sensitive development; the only means of mitigating adverse impacts is to use distance separation. This leads to inefficient land use planning, and an element of injustice, as the noise generator is effectively sterilizing neighboring land for nose sensitive development, at the cost of the neighboring land owner. Whereas it is possible that the noise generator could use BAT to reduce noise emissions; and the nose sensitive development could incorporate mitigation by way of the scheme layout, orientation and building form so that even though any residual adverse BS 4142 assessment may not change; acceptable noise conditions can be achieved

ANNOYANCE

Establishing design limits

The task in hand is to establish reasonable design limits for noise sensitive developments near industrial sources and threshold criteria for implementation of mitigation. Working on the basis of ensuring the equivalent of the *"avoidance of serious community annoyance is achieved"*, i.e. 55 dBA or below, an understanding of the possible annoyance response relationship to general community noise and to the specific industrial type noise in question is required.

Residual BAT for the most part concerns persons moving to an established noise source. Consequently, there is no need to take into account any synergistic influence that a change in noise conditions may have in causing a stronger adverse response than would be anticipated solely from looking at community response rates to steady state noise conditions.

Recent research reinforces that generally the A-weighted decibel provides a reasonably good indicator for predicting community annoyance from industrial noise; except where the noise contains a dominant low frequency component. The threshold of the onset of moderate annoyance for a significant majority of persons for steady-state, constant noise is around the continuous equivalent sound pressure level of 50 dBA. A few people are seriously annoyed during the day time at noise levels below around 55 dBA. With regard to industrial noise a comprehensive study in the UK concluded that "*in general there is no strong evidence that industrial noise produces higher annoyance response than transportation noise*". However, it is clear that any type of noise containing distinctive acoustic features such as tonality or impulsive elements may be more disturbing than another noise of similar level but without such features.

Objective assessment of noise impacts

In general, noise can act as a distracting stimulus and may also affect the psychophysiological state of the individual. A novel event, such as the start of an unfamiliar noise will cause distraction and interfere with many kinds of tasks. Noise annoyance may be defined as a feeling of displeasure evoked by a noise. Annoyance is affected by:

i. the equivalent sound pressure level,
ii. the highest sound pressure level of a noise event,
iii. the number of such events, and
iv. the time of the day.

The annoyance due to a given noise source is perceived very differently from person to person. It is also dependent upon many non-acoustic factors such as the prominence of the source, its importance to the listener's economy, and his or her personal opinion of the source.

Alternatives to BS 4142

The Standard BS 7445-2 (1991), ISO 1996-2 (1987) states that the Rating Level has to be determined over reference time intervals related to the characteristics of the source(s) and receiver(s). The Rating Level defined in ISO 1996 – 2 is a measure of the noise exposure corrected for factors known to increase annoyance. The basic

parameter is the A-weighted equivalent continuous sound pressure level or L_{Aeq}. The formula for the Rating Level is (in general terms):

$$L_R = L_{Aeq} + K_I + K_T + K_R + K_S$$

where:

K_I is a penalty for impulses

K_T is a penalty for tone and information content

K_R is a penalty for time of day

K_S is a penalty (positive or negative) for certain sources and situations e.g. low frequency dominated noise

ISO 1996 Corrections used in other countries

The reference time periods vary 5 minutes at night to 1 hour during the day, although a 15 minute period can be preferred overall by some decision makers. The penalty for tones varies between 0 dB (no penalty) and 6 dB. Some countries use a single penalty value of 5 dB, while other countries use two or more steps. In most cases, the presence of tones is determined subjectively, but objective methods are increasingly used. These methods are based on 1/3-octave or FFT (Fast Fourier Transform) analysis.

Corrections for impulsive noises

It is not possible to lay down definite criteria for impulsive sound, but it has been suggested in research that existing noise sources can be assigned to three different categories of "impulsive noise" (see Table 1).

1. ordinary impulsive sound,
2. highly impulsive sound, and
3. high-energy impulsive sound.

The maximum penalty for impulsiveness can vary up to 7 dB between countries, and both subjective and objective methods are used. The objective methods are based on the difference between a fast reacting and a slower reacting measurement parameter (for example, between Impulse and Fast A-weighted levels) or it can be based on the type of source, using a list enumerating noise sources (such as hammering, explosives, etc.).

Impulsive noise may be more annoying than non-impulsive noise where each of them produces the same equivalent level L_{eq}. Impulsive noise is rated by making "adjustments" to the relevant L_{eq} of the impulsive noise. There is a very wide range of possible adjustments for impulsive noise, from 2 dB up to 15 dB, depending on the circumstances. Regulations in European Countries lay down various adjustments (depending on the tradition in the countries concerned). Table 2 shows the adjustments made for impulsive noise in some European States.

Given the above it is not unreasonable to assume the single 5 dBA correction for tonality (although this could be further justified using a 1/3 octave band analysis of the data) and an impulsiveness correction of 5 dBA. In the UK, BS 4142 uses only one correction of 5 dBA to cover all acoustic features.

Table 1: Adjustments made for impulsive noise in some European States

Differences in tonal and impulse corrections for different countries		
Country	**KT in dBA**	**KI in dBA**
Austria	3 or 6	3 if $L_{A,I,max}$-$L_{A,F,max}$ <2 dB 5 if $L_{A,I,max}$-$L_{A,F,max}$ >2 dB
Belgium; Flemish	5 or 2 music : 5	$L_{A,I,max}$ <2 s difference $L_{A,I,max}$ and L_{Aeq} : <20 dB day, <15 dB evening and night
Belgium, Brussels	2 to 6	$L_{A,I,eq}$-L_{Aeq}
Belgium, Walloon	2 to 6	5 if $L_{A,I,max}$-$L_{A,S,max}$ >5 dB
Denmark	5	5
France	5	3 or 5 or 10 depending on duration and $L_{A,F,max}$-L_{Aeq}
Germany	3 or 6	$L_{A,I,eq}$-L_{Aeq} or $L_{A,FT,eq}$-L_{Aeq}
UK (only KT or KI)	5	5
Italy	3	3 if $L_{A,I,max}$-$L_{A,F,max}$ >6 dB , and $L_{A,F,max}$ <1 s, and N>10 in daytime or N >2 in night time.
Netherlands	5 (audible tones)	5 (audible impulses)

SLEEP DISTURBANCE

World Health Community Noise Guidelines

For night-time, noise sources the World Health Community Noise Guidelines (WHO 1999) recommend a night-time (23.00-07.00) noise level of 30 dB $L_{Aeq,8h}$ inside bed-rooms (for a reasonably steady noise source) and on a sleep disturbance basis the WHO guidelines state in Section 3.3 that:

"For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10-15 times per night....."

In 2003, the WHO Regional Office for Europe set up a working group of experts to provide scientific advice for the development of Night Noise Guidelines (NNGs) for future legislation and policy action in the area of control and surveillance of night noise exposure.

WHO Night Noise Guidelines for Europe (NNGS)

Since the publication of the initial NNGS in 2007 which were based on no observed adverse effects level (NOAEL), various comments were received regarding the achievability of the guideline values. In response the WHO in consultation with inter-national experts and stakeholders including the EU, agreed that the guidelines should be based on the lowest observed adverse effects level (LOAEL) rather than the NOAELs. In addition, an interim target was also introduced as a feasibility-based

guideline. These findings were published in 2009 and it is this version of the Night Noise Guidelines for Europe (NNGS) that are current. The latest NNGs do not supplant the existing WHO Community Noise Guidelines (WHO 1999) and are described in the document as complementing them.

The NNGs specify use of the cumulative annual metric L_{night} – the annual average equivalent sound level between 23:00 and 07:00 — to protect against sleep disturbance. There are two recommended values as follows:

- Night noise guideline (NNG) $L_{night,outside}$ = 40 dBA
- Interim target (IT) $L_{night,outside}$ = 55 dBA

Internal noise conditions at night

The NNGs are widely exceeded across the UK and Europe. Furthermore, it is clear that use of the ultimate NNG target will result in costs to both individuals and society overall that are substantial e.g. cessation of virtually all public and private transport and severe curtailment of much economically and socially useful activity at night; and exclusion of large swathes of land from noise sensitive development. Currently, neither the UK government nor the devolved administrations have incorporated the WHO Night Noise Guidelines into policy or indicated that they are likely to do so.

Indeed, given that the Noise Policy Statement for England at paragraphs 2.20 and 2.21 reinforces that it seeks to avoid "*significant adverse impacts*" and distinguishes these from the more stringent "*Lowest Observed Adverse Effect Levels*" used to set the WHO's ultimate night-time noise target; it is clear that noise policy in England does not promote or otherwise sanction the ultimate WHO night noise target of $L_{night,outside}$ 40 dBA as an overall policy objective. Instead as a more sustainable control, where appropriate, it is expected that internal noise conditions at night can be managed by using noise sensitive scheme layout, orientation and building form to achieve acceptable internal conditions; albeit subject to suitable provision for ventilation. The noise levels to be aimed for internally are the guideline values for within bedrooms from the earlier WHO Community Noise document.

Free-field noise conditions at night

Consequently if the use of BAT by an operator means the noise levels from an EPR/IED installation does not exceed 45 dBA $L_{Aeq,t}$ or 60 dBA L_{Amax} under free-field conditions; noise would not be a material consideration for the noise sensitive development of the affected land.

On the other hand, if despite the application of BAT by the operator the noise level from an EPR/IED installation does exceed 45 dB $L_{Aeq,t}$ or 60 dB L_{Amax} under free-field conditions; noise would be a material consideration for the noise sensitive development of the affected land; and any scheme would need to incorporate measures to reduce predicted internal noise levels in bedrooms to below 30 dB $L_{Aeq,t}$ or 45 dB L_{Amax} as appropriate.

CONCLUDING REMARKS

Although conventionally used in the UK to assess industrial noise, BS 4142 is inappropriate for the assessment of existing industrial noise on proposed new noise developments. Although the new scheme can incorporate mitigation to achieve acceptable noise conditions, the BS 4142 rating level may not change. Instead it is

considered appropriate to rely on absolute noise level targets appropriately adjusted for acoustic features as recommended in ISO 1996/BS 7445. Appropriate design standards for industrial noise can be based on WHO Community Noise guideline levels suitably adapted for acoustic character as per ISO 1996/BS 7445.

In regard to annoyance, it is not unreasonable to assume the single 5 dB correction for tonality. This can be further justified using a 1/3 octave band analysis of the data. An impulsiveness correction of 5 dB could be justified by further integration of the gathered data. For tonal noise with impulsive elements, this then leads to a potential mitigation external design target of 55 dB - 10 dB = 45 dB $L_{Aeq,t}$.

With regard to sleep disturbance, the WHO NNGS are regarded as too restrictive and impracticable. Instead, for night-time noise sources, the World Health Community Noise Guidelines are preferred i.e. night-time (23.00-07.00) noise level of 30 dB $L_{Aeq,2300\ to\ 0700h}$ inside bedrooms (for a reasonably steady noise source) and indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10-15 times per night. Where the noise source is not steady, the time period t for the 30 dB $L_{Aeq,t}$ shall reflect the duration of the higher noise levels within the operational cycle.

A simple risk assessment can enable the relative risk to the industrial noise source and the occupiers of any new nearby noise sensitive development to be evaluated and appropriate measures to be enforced on either the noise emitter by the Environment Agency, on the new noise sensitive scheme; or both.

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